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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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A Railway Centenary

The British people gave the world the railway, and by that means ushered in the age of rapid transit which has continued ever since through the subsequent development of the petrol engine and the oil engine, both of which have been applied to transport both of passengers and goods by land, sea and air. It is said that civilisation began with the first road, and these developments, if they have made the world incredibly smaller, have also made it possible for millions of people to move more freely and to enjoy products brought from the ends of the earth in a way that makes older civilisations seem parochial by comparison.

It was some ten years after the opening of the first railway from Stockton to Darlington that Parliament passed the Act, in 1835, that created the Great Western Railway, and more perhaps than any of the other great lines it has suceeded in preserving intact its special individuality and its original name. There could be no event in subsequent railway history quite so epoch-making as the invention of the railway itself, but this must not be allowed to obscure the steady progress that has since been made. British engineers have brought the locomotive based on the original reciprocating steam engine to such a pitch of perfection that revolutionary changes such as the turbine locomotive, the electrical drive and the Diesel car have the greatest difficulty in demonstrating their superiority, either for general main-line or suburban services, although all the railways are experimenting and using these developments as well as launching out into road and air traffic. The railways are great makers, users and buyers of castings of all types, iron, malleable, non-ferrous and steel, and their foundries are admirable examples of the production both of high-class castings such as cylinders and equally of the mass-production types such as railway chairs. The praiseworthy new spirit in developments and in public relations which is now being appreciated by travellers is demonstrated equally in their industrial works, which is shown in an anxiety to test and adopt new ideas. Travellers will wish all the lines good luck in their endeavours. The human touch was well shown at the end of the admirable broadcast to celebrate the G.W.R. centenary, when their oldest pensioner, in his hundredth year, mentioned that he recalled the last broad-gauge train to leave London, and thus provided the living link with what the young student to-day regards as very ancient history. There must be many middle-aged to elderly people who can recall travelling in a broad-gauge train, the last of which ran in 1892.

The Three S's

Sometimes after spending a day in a foundry we receive the impression that the fundamental properties required from castings are being relegated to the background and that isolated metal properties are being stressed unduly. Some executives are enthusiastic as to control of composition and emphasise according to the particular school of thought which appeals to them, low sulphur, finely-divided graphitic carbon, or, may be, the sorbitic character of the pearlite. Others are particularly proud of the tensile, transverse or bend-test results.

This tendency in thought and aspiration is due no doubt to specificational postulation, which inclines to accord to these properties an importance of an exaggerated character. The main features to be expected from a casting are dimensional accuracy, soundness—involving a freedom from cracks, scrabs, tears, segregation, blow-holes and pipe—easy machinability, wear resistance and perhaps non-growth, chemical and natural corrosion and heat resistance. Skin or surface is in many cases of paramount importance, but because of the difficulty in expressing its worth as a numerical value it is inclined to be forgotten. A few metallurgists, especially a group centred in the East Midlands, have recently been devoting considerable attention to tolerances as related to dimensional accuracy. Soundness, too, is not easy to express simply, but the lead given by the first "Cast Iron Report" issued by the Technical Committee of the Institute of British Foundrymen paves the way for more concentration of thought and considered opinion by more foundry executives. The evaluation of surface still awaits elucidation, though a little work has been done by American investigators.

It should be clear from the above that more effort ought to be made in the future to give equal importance to the fundamental requirements of castings as to those properties which are of interest to the designer or metallurgist, and where possible to correlate isolated figures with basic considerations. Finally, we wish to emphasise that in writing this article our intention is not to belittle the obtaining of metal to fine limits of chemical tolerances, and not to minimise the importance of the production of high-tensile material nor to bestow upon it any other outstanding property, but rather to call attention to those fundamental properties of shape, surface and soundness which are insufficiently prominent in the minds of many executives.

XUM

The Institute of Vitreous Enamellers

SECOND ANNUAL CONFERENCE IN LONDON

The second annual Conference of The Institute of Vitreous Enamellers, to be held on September 27, 28 and 29, will be inaugurated by a banquet and dance in the Edward VII Rooms, Hotel Victoria, Northumberland Avenue, London, W.C.2. Mr. Frank Hodges, J.P., and Mr. S. C. E. Lloyd, of Messrs. Stewarts and Lloyds, Limited, have kindly consented to attend the banquet, and they will be supported by prominent leaders of industry, commerce and scientific societies closely connected with the enamelling industry.

Programme

Friday, September 27, at Hotel Victoria, Northumberland Avenue, London, W.C.2.

7 p.m.—Reception by the President of the Institute, Dr. J. W. Mellor, F.R.S., and Mrs. Mellor.

7.30 p.m.—Banquet.

9.30 p.m. to 2 a.m.—Dancing in the Edward VII Room to Phil Raymond and his London Cabaret Band. Entertainment by Norman Long at the piano, and Shuan McAlister, magician.

Saturday, September 28.

9 a.m.—Assemble in hotel foyer.

9.15 a.m.—Leave hotel by motor coach for visit to the works of Messrs. Belling & Company, Limited, Enfield, Middlesex.

9.45 a.m.—Arrive at Enfield.

12.15 p.m.—Leave Enfield by motor coach for Shipping, Engineering and Machinery Exhibition, Olympia, London, W.14. (Admission by kind invitation of the organisers.)

12.45 p.m.—Arrive at Olympia. Members will make their own luncheon arrangements in the public restaurants open in the exhibition.

3 p.m.—Technical meeting in Olympia boardroom.

(*a*) Presidential address.

(*b*) Chairman's remarks.

(*c*) Paper: "Common Defects in Vitreous Enamelling on Cast Iron, Sheet Iron and C.R.C.A. Steel," by C. P. Stone.

(*d*) Discussion.

5 p.m.—Tea. Members will be entertained by kind invitation of the Exhibition Organisers. A card will have been sent to members under separate cover.

Sunday, September 29. Private car rally.

10 a.m.—Leave hotel by private cars.

12 noon.—Arrive Burford Bridge Hotel, near Dorking, Surrey, for morning cocktails.

1.30 p.m.—Picnic luncheon on Leith Hill, Surrey, or hotel luncheon near to, depending on climatic conditions.

4.30 p.m.—Tea at Westerham, Kent.

Publication Received

The Pipe Foundries of the Staveley Coal & Iron Company, Limited, Chesterfield. This booklet differs from so many of its kind, in that it is essentially readable, whilst the illustrations are well chosen, the lay-out is excellent, and the binding particularly attractive. The brochure is of special interest to our readers, as it describes the manufacture of sand-spun pipes in such considerable detail that it can be regarded as a reliable textbook on the subject. We congratulate the publicity department of the Staveley Company on the production of what can be regarded as a credit to any technical library.

Duties on Lead and Zinc

Under the Import Duties (General *Ad Valorem* Reduction) (No. 1) Order, 1935, made by the Treasury on the recommendation of the Import Duties Advisory Committee, the Customs duties on unwrought lead and zinc are from August 27, 1935, 7s. 6d. and 12s. 6d. per ton respectively, or 10 per cent. *ad valorem*, whichever is the least. The reduced duties now recommended are a part of revised arrangements proposed by the Committee in a special report dated July 2, 1935, to the President of the Board of Trade, on the working of the agreements made at the Ottawa Conference regarding lead and zinc. Under these agreements the United Kingdom Government undertook to maintain the general *ad valorem* duty of 10 per cent. on these metals as long as Empire producers were willing and able to offer them on first sale in the United Kingdom at prices not exceeding the world prices and in quantities sufficient to supply the requirements of the consumers. Under the new recommendations there will be no obligation on either side to supply or buy Empire metal.

A Personal Invitation

Mr. J. Léonard, the President of the Belgian Foundrymen's Association, has sent us for publication an open invitation for British foundrymen and their ladies to participate in the forthcoming congress which will be held from September 20 to 25 in Brussels. His invitation is so charmingly worded that we reproduce his letter and a translation below it.

A. T. F. B.

Association Technique de Fonderie de Belgique

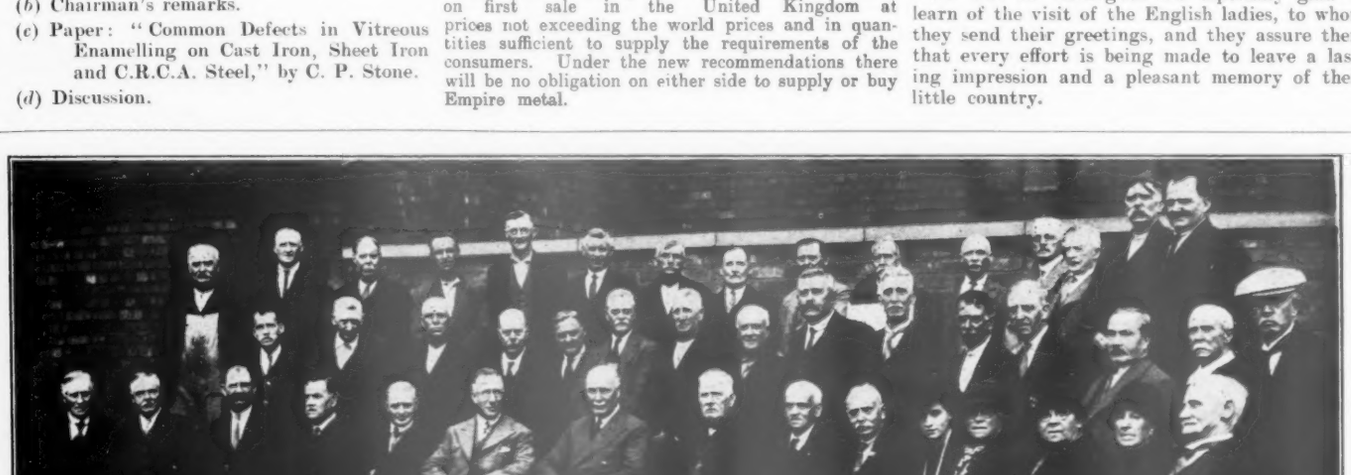
PRÉSIDENCE GRIVEGNÉE, 10

Translation

The President wishes to convey to the British founders proposing to attend the Brussels Congress his pleasure at their acceptance of the invitation of the Belgian Foundry Technical Association.

He hopes they will have a pleasant journey and derive satisfaction not only from the visit, but from the scientific and technical points of view. They may be assured of a very cordial reception.

He and his colleagues are especially glad to learn of the visit of the English ladies, to whom they send their greetings, and they assure them that every effort is being made to leave a lasting impression and a pleasant memory of their little country.



NO LESS THAN FORTY-THREE OF THESE EMPLOYEES OF MESSRS. LEY'S MALLEABLE CASTING COMPANY, LIMITED, OF DERBY, HAVE HAD FORTY YEARS OF SERVICE WITH THE FIRM. THEY HAVE BEEN THE RECIPIENTS OF CERTIFICATES AND A GIFT FROM SIR GORDON LEY, BT. (SEEN IN THE CENTRE).

Influence of Aluminium on the Properties of Ordinary Cast Iron*

By MARCEL PLOYÉ

Introduction

In this study aluminium additions in grey cast iron have been investigated from the point of view of improving the properties of ordinary commercial castings, bearing in mind the fact that such improvement, if it is to be of interest to industry, must be commensurate with the extra cost of the alloy additions. On this basis the work has been divided into two parts, firstly, an investigation into the possibilities of improving ordinary grey iron by means of very small additions, and, secondly, a search for irons of special properties resulting from more substantial additions of aluminium.

Small Aluminium Additions

In the first part of the work the influence of additions up to 0.25 per cent. of aluminium made to a cupola iron of motor-cylinder quality was investigated. After considering various methods of making the alloy addition the author standardised on the use of sheet clippings, which were added in the ladle and held below the surface of the iron until completely melted and alloyed. Stirring was used to assist in the liberation of aluminium oxide and a flux of common salt was used to provide a covering for the purpose of reducing oxidation to a minimum.

In this part of the investigation aluminium additions of 0.02, 0.05, 0.1 and 0.25 per cent. were used and three series of irons were made up, as follow. In the first place the alloy additions were made to the iron immediately it was tapped from the cupola and castings were made from this both hot and after being held for some time and allowed to cool to a temperature of 1,220 deg. C. In the third series the iron was allowed to stand in the ladle till almost too cold to cast and was then alloyed with aluminium as before.

In each series, test-bars were cast to provide data on the fluidity of the iron, tendency to chill, and mechanical properties in round bars varying from 0.79 in. (20 mm.) up to 3.15 in. (80 mm.) in diameter. The need to reduce oxidation to a minimum was recognised, and in addition to the sodium-chloride flux used the metal was handled throughout in tea-pot type (syphon) ladles.

Test Results

The results of the above tests showed that small additions of aluminium added direct to the iron from the cupola gave improved fluidity, due, it is concluded, to the deoxidising effect of the addition. The fluidity was at a maximum with the addition of 0.02 per cent. of aluminium. The addition of aluminium under all conditions progressively reduced the tendency of the iron to chill, thus confirming the conclusion of previous authors that in this respect aluminium acts in the same manner as does silicon. Microscopic examination showed that in general aluminium had little or no effect, except for a slight coarsening of the graphite in the case of the iron alloyed hot and cast at the lower temperature. The metal alloyed and cast at the low temperature was unsound and contained many inclusions.

The mechanical-test results did not show any striking influence from the aluminium addition and no tendency to equalise hardness in varying section was manifest. Slight increases in hardness (5 to 10 points Brinell) and in strength were recorded in the series of irons alloyed hot.

High Aluminium Series

In the second section of the work special irons with aluminium contents up to 20 per cent. have been studied. Three base irons were used, the first with carbon 3.4 and silicon 2.3, the second with carbon 3.8 and silicon 1.08, and the third with carbon 2.5 and silicon 2.3 per cent. Manganese was approximately 0.7 to 0.9, with phosphorus and sulphur low. In each case 100 kgs. (220 lbs.) of the iron was melted in a crucible furnace and aluminium was added as an alloy containing 94 per cent. of aluminium. In the first place, after a blank test had been taken, the remainder of the metal was alloyed with 0.5 per cent. of aluminium and a further 10 kgs. taken for test-pieces. The remaining metal was further alloyed to bring the aluminium up to 1 per cent. and more test-pieces were cast, this procedure being repeated until the last 10 kgs. had the alloy content raised to 20 per cent. of aluminium. Actually, as the records show, the loss of aluminium was higher than expected and in the various series the final aluminium content varied from 15 to 18 per cent.

In the case of each alloy composition, test-pieces were cast for studying mechanical properties and chill, aluminium levels in the case of each iron being 0.5, 1, 2.5, 5, 7.5, 10, 15 and 20 per cent.

The metal in the crucible was maintained at a temperature of 1,400 deg. C., the iron being reheated as necessary between each addition. With the smaller additions of aluminium it was noticed that a kind of skin was formed on the surface of the melt and as the proportion of aluminium increased this skin broke up, giving a number of flocks or inclusions in the metal. The volume of these inclusions increased rapidly with the aluminium. With the high aluminium contents a scum was formed on the melt which was as great in volume as the liquid metal beneath, in spite of the fact that the metal was skimmed between each addition. A peculiar phenomenon was also noted in the case of the iron alloyed with 20 per cent. aluminium, in which case a form of kish was thrown up out of the bath.

Test Results

In studying the chilled test-pieces it was found that from 0 to 2 per cent. of aluminium the chill was decreased whilst from 2 to 7 per cent. the depth of chill was small but constant. From 7 to 10 per cent. the depth of chill rapidly increased until the whole of the fracture was white, and no change was noted in this condition until above 15 per cent. of aluminium a decrease in the depth of chill occurred and graphitised iron reappeared behind the chill.

In the records of the chemical analyses it was found again that the combined carbon present was at a minimum between 2 to 7 per cent. of aluminium, but all the carbon present was in the combined state between 10 and 15, after which the proportion of graphite slowly increased again.

Microstructure

The results of the microscopic examination of this series can be summarised as follow. With aluminium between 0 to 2 per cent. no striking change in microstructure is noted apart from the elimination of excess carbide, which would be anticipated in view of the effect of aluminium in eliminating chill. From 2 to 5 per cent. a progressive change in the condition of the pearlite takes place and the author refers to the formation of the second modification of pearlite. From 5 to 8 per cent. a gradual decomposition of the second form of pearlite is noted with the appearance of complex carbide crystals. From 8 to 10 per cent. the structure is described as a mixture of complex carbides with a secondary form of ferrite. From 10 to 15 per cent. a rapid increase in the amount of carbides present takes place at the expense of the ferrite. From 15 to 20 per cent. the amount of carbides decreases and a matrix of ferrite and graphite remains.* The above observations on changes in microstructure with increasing aluminium were confirmed in a series of dilatometric tests, but these tests do not appear to have led to any further useful conclusion.

Mechanical Tests

A series of hardness tests showed, as might be expected from the microstructure, a gradual increase in hardness up to about 8 per cent. of aluminium, after which the hardness rapidly increased, reaching a maximum in the region of 11 to 14 per cent. of aluminium, at which composition, of course, complex carbides are present in maximum proportion. The Brinell hardness in this range reaches a maximum of about 550. In both the shear and transverse tests the first additions of aluminium appear to increase the mechanical strength, whilst above 8 per cent. with the increase of combined carbon the castings become brittle and the strength results are poor. In the case of the transverse test, maximum strength occurred in the region of 0.5 to 1.5, according to the composition of the base iron, the maximum results being, of course, obtained with the low-carbon, low-silicon base.

In relating the results of the mechanical tests with microstructure, the author quotes:—

Between 2 to 8 per cent.—With the decomposition of pearlite the progressive disappearance of graphite and the appearance of the new crystals of the special carbides we have a characteristic increase in hardness and in the shear test and a reduction in the rupture stress in the transverse test.

Eight to 15 per cent. of aluminium.—With the final disappearance of pearlite and of free carbon replaced by about 60 per cent. of special cementite and 40 per cent. of secondary ferrite we have a loss of mechanical properties with excessive hardness, that is to say, the alloys are hard and brittle, characteristics of a metallic compound.

Above 15 per cent.—The reappearance of free carbon and the decomposition of carbides gives a gradual increase in mechanical properties and a return towards machinability and the diminution of hardness.

Special Properties

In fulfilling the object of the second part of this work, the cast irons in the series 0 to 20 per cent. of aluminium were studied from the point of view of their heat resistance, corrosion resistance and suitability for nitrogen-hardening.

Heat-Resistance

The irons in this series were studied both from the point of view of carbide stability and oxidation resistance. Considering first the question of carbide stability, it was found that with up to 4 per cent. of aluminium the combined carbon was unstable on heating and tended to break down exactly as in the case of ordinary cast iron. This instability of the carbides tended gradually to diminish as the aluminium was increased up to 8 per cent. and in the range 8 to 20 per cent. of aluminium, where the irons are unmachinable, the carbides proved stable and no growth on account of formation of graphite occurred, in fact, many of the test-pieces showed slight contraction.

(*Concluded on page* 163.)

* Abstracted from "Revué de Métallurgie," June, 1935, pp. 248-270, and July, 1935, pp. 302-320.

* The secondary form of ferrite may be austenite.

French and British Strickle Moulding Practice Compared

A WELCOME CONTRIBUTION

The French Exchange Paper, presented to the Sheffield Conference—"Strickle Moulding of Large Castings,"* by H. Fabre and H. Dubois—was particularly well received as being an outstanding contribution to the art of moulding.

The discussion was opened by MR. J. J. MCCLELLAND, who said he had only one grumble to make in connection with the Paper, but, from his point of view, he regarded it as a serious one. He regretted that it had not been possible for the authors to attend the Conference, and, at the outset, he wished to state that he could not understand why they should both begin and end their Paper by making apologies. It was a type of Paper which was necessary, and there was no necessity whatever to apologise for introducing its subject-matter for the consideration of the Conference. It appeared, however, to be somewhat lacking in detail. It would probably have been improved if there had been fewer illustrations and a little more detail given in respect to each illustration. He would instance Fig. 2. He would like to know whether the brick work shown in the core, particularly in the upper portion, was a single row of bricks. There was no indication that it was otherwise. Personally, he did not think that a single row of bricks in the case of a core of such dimensions, with a casting weighing 12 tons, could resist the strain of the metal when the casting was made. There did not appear to be any kind of packing to strengthen the brick work.

Running Information Lacking

A formula had also been given for working out the area for runners, but it was not stated how the runners were to be placed nor how the metal was to be put into the casting. In one or two cases, reference was made to risers but there was no illustration as to how runners should be placed.

In regard to Fig. 3, was it to be understood that the loam brick referred to would be sufficient to counteract the contraction of the casting? It was not indicated whether there should be any splitting of the lifting plate to comply with the contraction elements. Were the loam bricks relied upon to overcome the difficulty of contraction?

Fig. 7 appeared to indicate a somewhat expensive way of making the arms for the job. Why was not the ordinary practice of making cores sufficient? The authors of the Paper seemed to build up the arm in two halves in loam, which were secured together by backing plates for placing in position. Was not this a cumbersome method and could it not be more easily done by making cores?

Fig. 10 showed a method of making the core for a mould. There was no clear indication as to how the air was to be abstracted in casting, nor was there any illustration as to how the core was to be handled and placed in position in the mould. Further information appeared to be necessary in regard to those points.

Certain information was given with respect to top parts, but those were jobs which were not made in every foundry, as a matter of fact there were thousands of foundries where that kind of work was never seen. In order to enable the practical side of the industry to become well acquainted with that type of work more Papers of the kind should be read before the Institute. An item in connection with the propeller illustration required qualification with regard to the fractional figures shown along the centre line of the blade. It would be observed that it began near the hub where the thickest part of the metal was, with a quarter section, and at the extreme end of the blade, where the thinnest part of the casting was, it was fifteen-sixteenths. Without further explanation of what those figures meant, a student would probably be very much led astray.

There was a large number of practical men present at the Conference and he hoped they would take the opportunity of supporting his suggestion that more Papers of the kind submitted should be read before the membership of the Institute and for the benefit of the Industry as a whole. He was quite convinced also that they would be of benefit and interest to the technical members of the Industry.

Strength of Core Bolts

MR. J. ROXBURGH said that when the Committee were contemplating the choice of suitable Papers for the Conference they felt, in Sheffield, that it would be desirable to have one of a practical nature. Therefore, they suggested to the *Association Technique de Fonderie* that such a Paper should be supplied by one of their members.

With reference to the Blackpot, Fig. 2, Mr. McClelland had suggested that one brick was insufficient for a job of the size mentioned. Personally, he was of opinion that one brick was sufficient. His own firm had made quite a number of castings of a similar nature, for example, chemical pots. In deciding the method which should be adopted for such a job a great deal depended upon whether one only or more were required.

Fig. 4 was quite a useful illustration of striking the back part of the core and it definitely saved the trouble of turning over a top plate. By turning the top plate over the core would be struck on the top plate. It would then have to be bolted up and rolled over, which caused quite a considerable amount of trouble in the foundry. By striking the back part, first of all, turning it over, and then building a single row of bricks, and bolting it up to the top plate, the trouble of turning the top part over was eliminated.

A point which occurred to him was that of the size of the bolt to be used for bolting up the core on to the top part. He had had an experience some years ago where the bolts used for bolting the core on to the top plate were not sufficiently strong, with the result that the core moved, and the casting was of unequal section. It was essential that the bolts used should be of sufficient diameter and sufficient strength to counteract any such possibility arising.

More or less orthodox methods were advocated in the Paper for the various jobs mentioned which did not really call for a great deal of discussion, but nevertheless the authors of the Paper were to be congratulated upon dealing with them in a very practical manner.

Split Crown Plates

MR. J. MASTERS also wished to congratulate the authors upon the practical nature of their Paper. He noticed that the seating on the top plate was located on the wrong side. The remark had been made that there was not really much room for discussion of the Paper. Personally, he thought there was so much scope for discussion that in order to do the Paper full justice, there ought to be an extended session. Mr. McClelland had dropped a hint with regard to the making of the pan, and there was no doubt that, in making pans of the size indicated, the crown plate should be split in order to slide past the spindle. Personally, he had been responsible for hundreds of pots, and it was his practice to build the core on the plate and turn over the whole. He only used a 9-in. wall, which was buttressed in three places, in which three staples were cast for the supporting bolts, until it came to the crown plate. Those bolts were of sturdy dimensions, namely, 2-in. dia. It did not appear to be necessary to have six bolts on the inside of the core, and only three to hold them in position. The pressure on the casting referred to in the Paper was, approximately, 100 tons. He did not think the authors of the Paper would make a casting of that description with outside brickwork, without ramming it in afterwards, otherwise trouble would ensue. He used to cast these particular pots in prodded binders, without ramming them up. The top plate was quite 6 in. thick, there being a very good metal consistency.

With regard to runners, the authors of the Paper would have been well advised to have included some idea of their methods of running. He thought it must be agreed that the only way of running them satisfactorily was from the top and all round the job. This was his own practice, and he obtained 100 per cent. good results, never having a cracked pot. The pots on the bottom ranged from 5- to 7-in. thickness, and, of course, the pressure was tremendous, yet there was not a single leak. It would have been better if the authors of the Paper had shown a different building of the core interspaced with the loam bricks to take off contraction stresses during cooling. He used to lift out the pots two days after they were cast and use the same outside structure again. There did not appear to be any utility in having three crown plates. One crown plate of suitable design was quite suitable to eliminate a fair amount of contraction in the mould and to obviate a large amount of extra work. He built his cores in the reverse position to the way the authors of the Paper built theirs, and turned them out without failure.

MR. J. H. PEARCE, in moving that a hearty vote of thanks be accorded to the authors for their most interesting communication, said that such a Paper was very welcome to the members of the Institute.

The PRESIDENT, in seconding the vote of thanks, did so with greater pleasure because he was a party, along with the Sheffield Council, in trying to obtain the Paper. Several of the members of the Sheffield Branch Council had made extensive tours on the Continent, and had formed the opinion that loam moulding was much more extensively practised in Continental foundries than in Britain.

The vote of thanks was carried by acclamation.

Written Communication

MR. E. LONGDEN, Manchester, wrote:—Whilst agreeing with the authors of the French Exchange Paper on strickle moulding that loam moulding has often been dealt with, it was not necessary to apologise. Only the fringe of the subject has yet been touched by the various practical foundry writers and we are indebted to the authors for presenting a sensible, practical paper.

The excellent Paper on "Castings" by Mr. Machin and Mr. Oldham emphasises the long practical and technical training necessary to produce large and complicated castings in loam.

Speaking broadly loam moulding certainly calls for a special type of skilled moulder. It was in this phase of foundry work that a sound knowledge of mathematics and drawing would be found to be invaluable.

The decision whether to produce a certain design of casting in loam by sweeping with strickles, or by the use of a skeleton pattern, a half pattern or a full cheap pattern and, in some cases, by cores, can only be truly arrived at by a foundryman of wide experience. It is very often a moot point whether loam pays.

* FOUNDRY TRADE JOURNAL, July 11, 1935, page 34 *et seq.*

Loam moulding is not always practised because pattern and moulding costs together are at the minimum. Many castings are made in loam because it is the safest form of mould for special and intricate castings of medium and heavy weight. Sometimes a mould may take several weeks to locate cores, or another mould may require considerable handling of both parts of the mould and cores. In such cases the strong loam mould withstands the wear and tear and movement of moulders and cores etc.

It is not the writer's intention adversely to criticise the Paper on strickle moulding, but to add just one or two points of view.

Cost Consideration

In many instances the cost of providing loam tackle is very often lost sight of by managements. If the cost of special loam plates and binders, etc., is properly identified with the cost of the job then all is clear, but this is, unfortunately, not always so. In many foundry yards huge piles of loam plates can be seen which have only the remotest chance of being re-used. Such tackle is idle and represents unused capital. In a large number of cases the cost of tackle has been merged in the general overhead charges thereby masking the true cost of the casting made in loam. It is not uncommon to see a foundry make 60 tons of special moulding tackle to produce a 20-ton casting. In such a case it can be safely assumed that if the tackle is of no further use and is broken up as scrap a loss of £75 in metal alone is incurred if the normal pig iron and scrap mixture has been poured into the tackle. £75 will pay for much patternwork.

The authors' practice when producing the "Blackpot" is unduly expensive in the light of modern foundry practice. Advantage should be taken of portable drying stoves and it would then be unnecessary to transfer heavy moulds to the stove involving extra mould lifting plates and extra effort of moulding and handling.

In the writer's foundry castings similar to the "Blackpot" and large spindle castings for machine tools up to 22 tons are dried *in situ* by portable drying apparatus.

Pulley Moulds from Quarter Patterns

Strickle moulding of the 4-ton grooved pulley or flywheel would not quite commend itself to the writer as being the most economical method. Such a casting can be more accurately and cheaply made by a quarter pattern, or by making one core box to form the arms, a core box to make one twelfth of the rim and a half core box to produce the hub. To attempt to strickle grooves is rather a messy and tedious operation. Bores made from the section core box would carry the grooves very effectively.

Except with cores and protruding sections of moulds the writer does not permit the use of cinders in a loam mould. He finds that better drying is obtained by employing dry sand between the brickwork on the lower faces of a mould. Thoroughly dried loam is very porous. Binders on a confined lower face of a mould may act as centres for condensation of steam and so upset drying calculations and often create gas evolution during pouring, which impairs the metal and creates a fused-on condition of the sand facing the casting. Venting and drying of the bottom face of a loam mould is far better if cinders are omitted trusting to the gas openings created by the drying process.

The authors of the Paper do not state how the "Blackpot" was gated. It can be assumed that the casting was poured through a series of top-drop gates. No other mould material but loam would safely withstand the impact of the metal.

The "Blackpot" casting is a case where strickle moulding is definitely the best practice and that both moulding and alternating cost is low and cannot be improved by any other method. After the first casting, production is extremely cheap, due to the retention of the mould brickwork for subsequent castings.

Book Review

Molybdenum Steels. Prepared for High Speed Steel Alloys, Limited, by Julius L. F. Vogel, M.I.E.E., and W. F. Rowden. With a Foreword by Lord Riverdale of Sheffield. Price, 5s.

A short treatise on the manufacture and the application of molybdenum steels has been prepared by Mr. Vogel and Mr. Rowden for High Speed Steel Alloys, Limited, Widnes. As noted by Lord Riverdale in a short Foreword, High Speed Steel Alloys, Limited, represent a combination of steelmakers. They have therefore a very good opportunity to obtain interesting data concerning the use of the various alloys which this company supply.

This publication refers exclusively to molybdenum steels, and the reviewer has read it with particular interest, following a fairly extensive research on the constitution of molybdenum steels made nearly 25 years ago.

It is now the established custom of suppliers of steelmaking alloys to collect and disseminate information concerning the advantages accruing from the use of such alloys, and one must commend this action. The standard of information now put out in this way is very high, and represents, in many cases, serious contributions to information of both academic and practical value.

This little book on molybdenum steels is no exception. After a useful survey of steelmaking and manipulation, specific data is given concerning the effect of molybdenum as an alloying element, together with a number of useful examples taken from various fields of service illustrating the particular virtues conveyed by molybdenum as an alloying element. In no case are the claims exaggerated; in fact, as regards the value of molybdenum in steels for service at elevated temperatures, the data could have been amplified considerably. It is now generally recognised that molybdenum is the most effective addition for improving the limiting creep stress and (in combination with other alloys) in the production of steel for service at high temperatures which is free from embrittlement.

The whole of the data is sound, well presented and without using unnecessary superlatives makes out a very good case for molybdenum as an important alloying element over a very wide range of alloy steels. T. S.

Papers for the French Foundry Congress

The Papers appearing in the programme of the Foundry Sub-Section (Sub-Section V of the Metallurgical Section) of the International Congress of Mining, Metallurgy and Applied Geology, presided over by Mr. E. Ramas, President of the French Technical Association, and being held from October 20 to 26, are as follow (the Sub-Section will this year replace the usual National Congress):—(1) Official Papers (sponsored by the authors appointed by the Committee of the Metallurgical Section of the Congress):—Le Thomas: "Cast Iron and the Electric Furnace." Le Thomas and Ballay: "Special Irons." Tonceda and Gailly: "Malleable Irons." Bastien: "Casting Under Pressure." Léonard: "Lessons of the Brussels Foundry Congress."

(2) Paper presented under the auspices of the American Foundrymen's Association:—Reichert: "American Methods of Study and Control of Moulding Sands."

(3) Individual Papers:—Budnikoff: "Refractory Materials and Silicates." Mitinsky: "The Modulus of Elasticity of Cast Iron." Lissner: "Annealing Carbon in Black-Heart Malleable." Laissus: "The Cementation of Grey Iron." Ballay and Chavy: "Researches on the Casting of German Silver."

Influence of Aluminium on the Properties of Ordinary Cast Iron

(*Concluded from page* 161.)

In tests carried out by heating samples of the irons up to 800 deg. C. intermittently in a strong oxidising atmosphere it was found that with increasing aluminium up to 8 per cent. the oxidation resistance was improved and from 8 to 15 per cent. the irons were almost completely resistant. Above 15 per cent. a slight tendency to oxidation corresponding to the development of graphite occurred.

The conclusion from this section of the work, therefore, is that the aluminium irons offer possibilities from a heat-resisting point of view, but the most suitable compositions are ones which are unmachinable and which, as stated elsewhere, also give trouble in casting.

Nitrogen-Hardening Tests

In view of the well-known influence of aluminium on the nitrogen hardening of iron and steel, whereby the hardening process is accelerated, due to the carrier action of aluminium with nitrogen, tests were carried out on the machinable irons in this series, the irons in question containing 0 to 8 per cent. of aluminium and being submitted to the nitrogen-hardening process under three sets of conditions. The conclusions from these tests are that with increasing aluminium the degree of surface hardness attained rapidly increases up to 3 per cent. of aluminium, after which it gradually falls again. An investigation of the brittleness of the skin, however, as measured by its breakdown in hardness tests, shows that with increasing aluminium the skin is increasingly brittle, whilst measurements of the thickness of the skin show that this reaches a maximum at 2 per cent. of aluminium. Measurements of hardness variation in the depth of the skin show first a gradual falling off in hardness followed by a rapid fall as the bottom of the skin is reached.

Corrosion Resistance

An extensive investigation into the corrosion resistance of the iron in the range 8 to 18 per cent. of aluminium was undertaken. The results of these tests may be summarised as follow:—The irons in this series do not show any special resistance to attack by weak mineral acids, in fact, under many conditions the rate of attack was greater than for ordinary iron. On the other hand, the irons in the series showed almost complete resistance to attack by sea water, both in an immersion test and in a spray test.

Conclusions

In summarising this Paper, the author emphasises the special difficulty in obtaining sound castings with the higher contents of aluminium, whilst the irons showing the most interesting properties from the point of view of heat and corrosion resistance also suffer from the disadvantage of being unmachinable. The author mentions, incidentally, that the iron containing 18 per cent. of aluminium is non-magnetic.

The original of the above Paper is extremely full and readers who are interested would be well advised to refer to the original for additional data on the various points summarised above. For example, the question of the analysis of aluminium cast iron is discussed at some length, while the sections on microstructure, dilatometric results, nitrogen-hardening tests, corrosion resistance and so on are all given in great detail, and the Paper is completed by a good bibliography.

Messrs. G. A. Harvey & Company (London), Limited, have in hand a new housing estate at Charlton for their employees, work on the first section of which is now well in hand. The roads are practically completed and many of the first lot of houses will, it is hoped, be ready for occupation early this month.

XUM

Castings

By W. MACHIN and M. C. OLDHAM

(*Continued from page 153.*)

One of the small top parts being taken off is shown in Fig. 64. The various loose parts of the mould are each marked before being removed, enabling the moulder to put each part back into the same position when the mould is reassembled after being dried. Some of the marks can be seen around the edges of the top piece. All the small top parts have been lifted off and the large top part with feeders or headers is shown being removed in Fig. 65. The screwed links in the lifting tackle allow parts of the mould to be moved in an angular direction, which permits the removal of those loose parts that go to make the completed mould, without any serious breakage of sand, thus retaining pattern profile in the entire mould when completed. In Fig. 66 it will be noticed that all drawbacks have been removed with the exception of the one on the left, where preparations are being made to remove it.

The last drawback having been taken out, operations can now proceed for removal of the pattern. The overhang of sand from the drawback plate is carried with loose irons instead of, in many cases, cast-iron grids.

The removal of the first piece of pattern was, as is shown in Fig. 67, carried out with ease, illustrating the importance of pattern construction in accordance with foundry requirement. The withdrawal of the other main piece of pattern (Fig. 68) completes the strip of the mould, which is now ready for finishing, preparatory to being dried.

The bottom half, all in one piece, and all the various pieces comprising the complete mould are shown in Fig. 69. The method of construction of the bottom half has been carried out so as to enable drying operations to be undertaken effectively. After the mould has been dried, it is an easy matter to leave the fire at various parts of the mould and so retain warmth whilst the moulders continue working on the closing operations.

Fig. 71 shows that closing has actually commenced at one side, from where the fire has been removed to another section. The modern hot-air drier is not a very convenient unit to use on a job of this description, on account of the area being so large and the mould so shallow. It will be appreciated that on a large complicated job of this description five or six days are required to complete the operation of closing, during which period the mould would be cold, were not such a method employed as described for retaining the heat.

All the drawbacks are shown completely assembled in Fig. 72, as well as the contraction brackets added to the mould to tie together the heavy and light sections. The extreme thickness of some portions of the casting will be apparent, as demonstrated by the moulder seen trying the thickness under one of the drawbacks. He is actually standing in one of these portions of the mould doing his work. It will be of interest to note the hollow form of the drawbacks, which considerably assists in their removal during the easing stage.

The main top part is shown being put into position with feeders added in Fig. 73, all of which have been completed and the height added, to meet the amount of thickness to be fed in the casting. The hollow forms of the drawbacks are shown to be very flimsily built to allow of easy removal.

Once again a large number of feeders are used. In Fig. 75, one of the moulders can be seen descending the feeder to examine the mould, and to make certain that the joints of the top parts and drawbacks are lineable with the main body of the mould. Weights are used around the outside of the mould to pack to the pit sides instead of ramming up the pit with a great bulk of sand. This procedure enables the pit to be quickly stripped to allow the various pieces of the mould to be expeditiously removed when the easing operations begin. The process of removing the pieces of mould at the correct time is important, as any part of the casting held by ledges or projections in the mould, or cores, brings about the danger of contraction cracks, or hot tears.

The two ladles of molten steel are shown in position over the mould just prior to the commencement of the casting operation in Fig. 77. The larger ladle contains 21 tons of metal and the smaller one 2 tons. Two ladles are used in order to obtain quick filling of the mould, and to ensure all thin sections and fine edges being completely cast. The wooden rods shown are used to keep the ladles steady during the casting operation, and to prevent spilling of metal over the sides of the runner basins. The mould was poured in 9 min., equalling 1 ton every 24 sec. Ten tons of metal were poured from the large ladle before the metal in the small ladle was released.

The two tons of metal in the small ladle, stationed at the point furthest away from the large ladle, heat up the surface of the metal at that part, giving a sharp cast result around the top of the casting. The metal in the larger ladle was produced from the Siemens open-hearth furnace and that in the smaller one from the Tropenas side-blown converter. The analysis of the metal in each ladle was the same within very fine limits.

Large castings, such as the one now being described, are more efficiently produced by means of two melting plants, thus enabling the mould to be run from more than one position. It is always useful, where large castings are made, to have a smaller type of plant available, as, if required, a further quantity of metal can be obtained for feeding purposes, after considerable shrinkage has occurred, some time after the mould has been cast.

The time of commencement of pouring is important, and is determined by the periods required for cooling the varying thicknesses of the casting. Prior to casting, the points at which easing will commence have been discussed, enabling the foreman to instruct the skilled and unskilled workmen accordingly.

The removal of the small top parts over the arms commenced about three-quarters of an hour after casting the job (Fig. 78), and it is interesting at this stage to note that the temperature at the end of the arms, at the finishing of the easing operations, was 250 deg. C., whilst that of the main body was above 850 deg. C. Two hours after casting, all the top parts and drawback plates had been removed, allowing the light parts of the casting to move freely towards the heavier portions. The casting is allowed to cool to shop temperature, being removed from the pit after about five days. The feeders numbered 1, 2, 3, 4 and 5 in Fig. 79, used for feeding the heavy sections referred to, can now be plainly seen. They are noticeable over the main stock of the rudder casting, and opposite each arm.

After the casting has cooled down to shop temperature, it is rough-dressed, and removed from the pit into the annealing furnace, where it is carefully supported all around, in order to retain its true shape during the annealing process. The annealing furnace is 30 ft. long, 25 ft. wide and 12 ft. high, totally enclosing the casting and giving uniform heating. The gas is supplied from a producer specially installed, with ports arranged so that the gas may be shut down at any part of the casting which may be getting too hot, and transferred to those parts requiring more heat, thus getting an even rising temperature. The annealing temperature is 900 deg. C. and the soaking period for a casting of this description is approximately 48 hrs. This casting was in the annealing furnace for one week.

FIG. 64.—THE SQUAD COMMENCING TO STRIP THE MOULD.

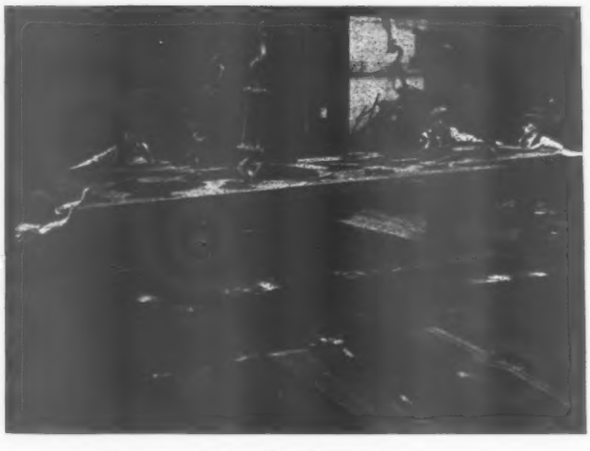


FIG. 65.—LARGE TOP PART BEING STRIPPED.

(*Continued from previous page.*)

Fig. 66.—The Removal of Drawbacks.

Fig. 67.—Removal of First Piece of Pattern.

Fig. 68.—The Other Main Piece of Pattern being Removed.

Fig. 69.—Mould Completely Stripped.

Fig. 70.—Showing Method of Drying.

Fig. 71.—Closing Operations Commenced.

(*Continued from previous page.*)

FIG. 72.—ASSEMBLED DRAWBACKS.

FIG. 73.—LARGE TOP PART BEING ASSEMBLED.

FIG. 76.—THE MOULD COMPLETED—THE VARIOUS PARTS BOUND TOGETHER TO THE BOTTOM PLATE BY MEANS OF CLAMPS AND CROSS-BINDERS.

FIG. 77.—CASTING OPERATION.

FIG. 80.—THE CASTING IN THE ANNEALING FURNACE.

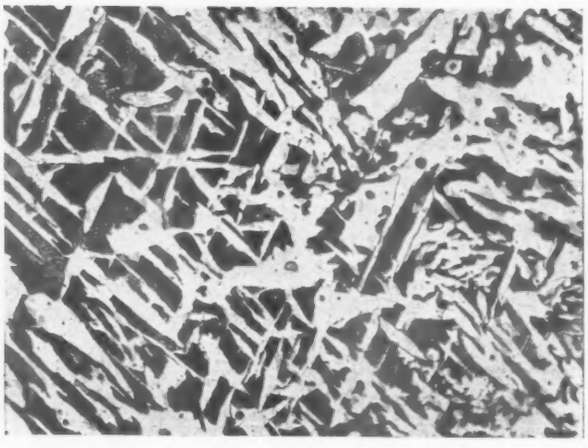


FIG. 81.—0.32 CARBON STEEL UNANNEALED × 100.

Fig. 74.—The Last Small Top Part about to be Put in Position.

Fig. 75.—The Final Top Part in Position, completing the Assembly of Mould.

Fig. 78.—Easing the Casting.

Fig. 79.—Easing Operations Completed.

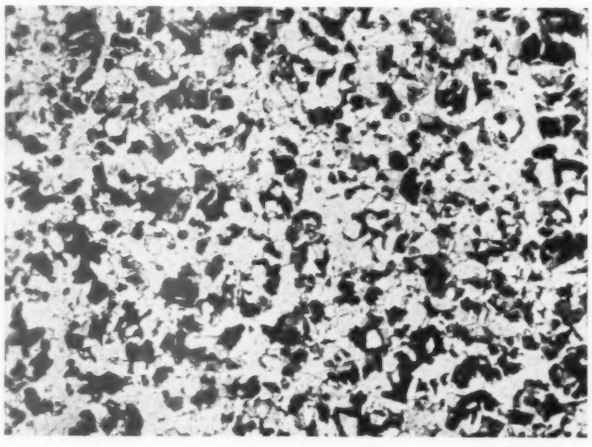


Fig. 82.—0.32 Carbon Steel Annealed. × 100.

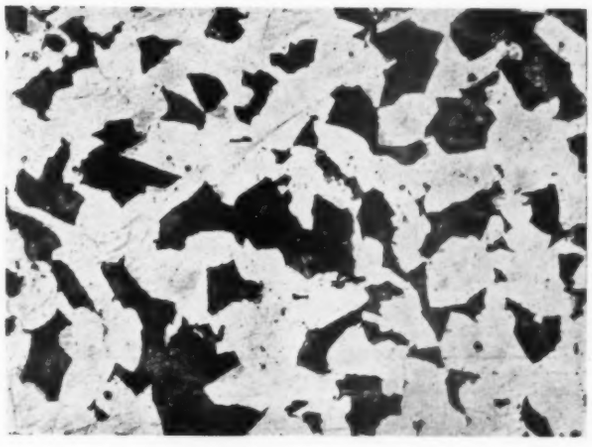


Fig. 83.—Mo Steel as Annealed. × 100.

XUM

(*Continued from previous page.*)

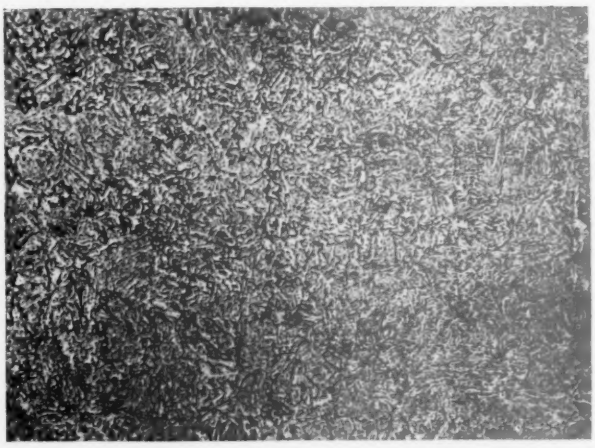


FIG. 84.—MO STEEL QUENCHED IN OIL FROM 900 DEG. C. TEMPERED FROM 600 DEG. C. × 100.

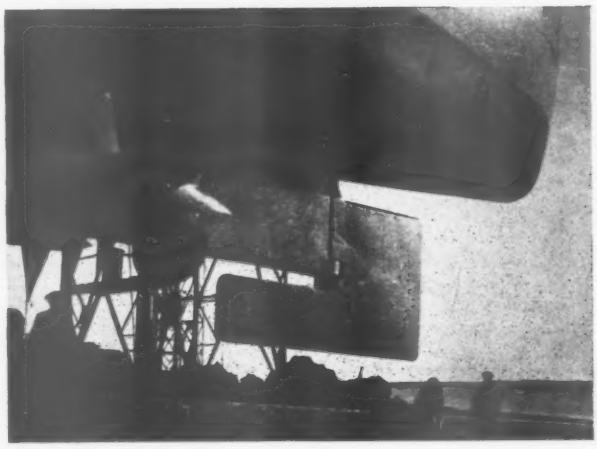


FIG. 87.—THE RUDDER FITTED TO THE SHIP.

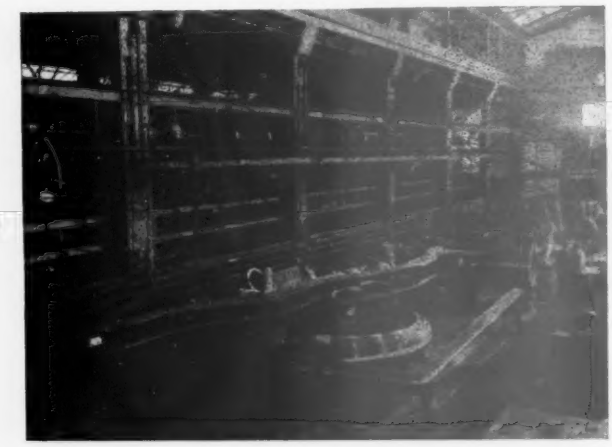


FIG. 88.—MODERN DESIGN OF STERN FRAME.

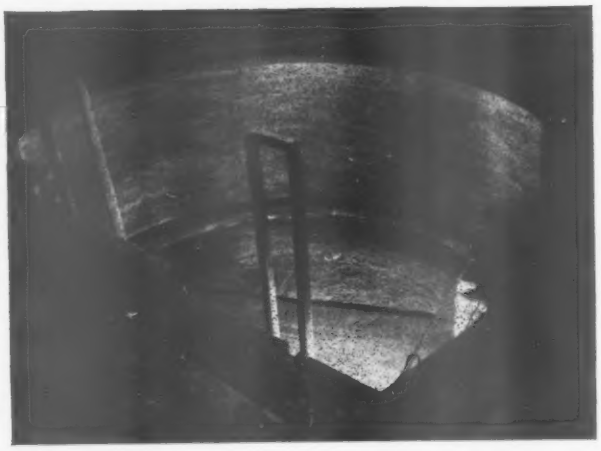


FIG. 89.—MOULD FOR CAST-STEEL DRUM FOR LARGE WINDER.

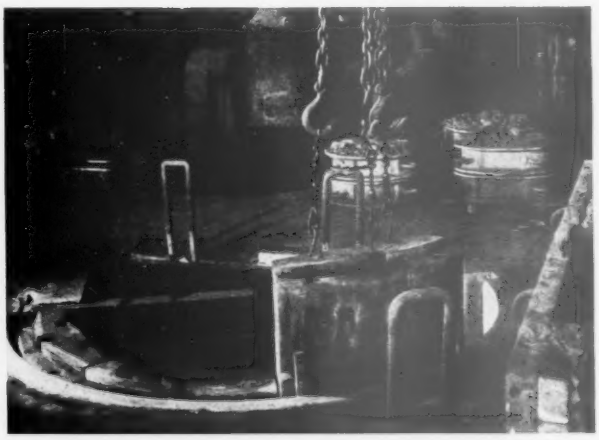


FIG. 90.—CORING-UP THE MOULD (FIG. 89).

FIG. 91.—DRESSING THE CASTING (FIG. 89).

(*Continued on page* 170.)

XUM

THE REFINING OF METALS BY THE SODIUM CARBONATE PROCESS

is being exhibited on

STAND 14, ROW D (F), in the FOUNDRY SECTION of the Shipping, Engineering and Machinery Exhibition at OLYMPIA on September 12th–28th

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Room 165E, IMPERIAL CHEMICAL HOUSE, LONDON, S.W.1

C.N.368

Castings

(*Continued from page* 168.)

The annealing of steel castings has a two-fold purpose, viz., to refine the structure which, after casting, is coarse, angular, and consequently brittle (Figs. 81 and 82), also to relieve stresses following cooling in the mould of the irregular-shaped masses in the design. These objects are attained by heating to a temperature above the upper critical point of the steel, usually from 850 to 900 deg. C., according to the carbon content in the case of both medium- and low-carbon steel, soaking for a time, depending upon the weight and sections of the casting, and subsequently cooling down slowly to produce the desired structure and freedom from contraction strains. With higher carbon steels and alloy steels, consideration must be given to the different temperatures which may be employed, as they are derived from the upper critical points of the materials in question.

Other important points are that the furnace, when charging the castings, should be cold, and the castings slowly heated so that thick and thin sections in the design are uniformly heated to avoid expansion stresses. As long a period as 9 hrs. may be required to heat, and 18 hrs. or even more to soak such a casting as, say, a steam chest weighing 2 tons. This would take approximately 24 hrs. to cool down Overhanging masses of metal require support, as, at the annealing temperature the metal is in a weak condition and distortion may occur.

The furnace gas ports also should be of such design that the flames do not directly impinge on any part of the casting. In addition, a large number of gas ports is desirable so that the gas may be regulated to meet heavy- and light-section thicknesses. Difficulties often arise with large castings in attaining a uniform temperature, and this can only be obtained by careful control in an annealing furnace of good design.

For important castings it may be desirable to take the temperature at different points, and this is done by attaching long thermocouples to various parts of the castings after positioning in the furnace, the thermocouples being led through holes in the furnace door and walls. Temperatures are taken at the various points by using a pyrometer indicator, and by this means the rate of heating can be adjusted to give a uniform temperature rise.

In the case of castings for high-temperature and high-pressure service, residual strains, which may be present after rough machining, are removed by a further heat-treatment. In these cases the castings are heated again to 650 deg. C., the heating time being 5 hrs., soaked for 3 hrs. and cooled slowly during a period approximating 12 hrs. A method of annealing also advocated is to heat to the upper point, cool slowly to a temperature below the lower critical point, say 600 deg. C., re-heat to a little above the lower critical point, say 750 deg. C., and then slowly cool. More complicated forms of heat-treatment, as by quenching and tempering, are also employed.

It is not generally realised that steel castings can be materially improved by such treatment, but great attention has been given to this point recently, especially on castings required for high-duty service. Steel castings produced in the authors' works, weighing several tons, have been successfully quenched and tempered, the following being figures obtained from steel containing 0.30 per cent. carbon and 0.50 per cent. molybdenum:—*Annealed.*—Yield point, 21.0 tons per sq. in.; U.T.S., 34.0 tons per sq. in.; Elongation on 2 in., 23 per cent.; and Brinell hardness, 143. *Quenched and Tempered.*—34.0 tons, yield point, 47.2 tons U.T.S., 17 per cent. elongation and 269 Brinell hardness. The increase in mechanical properties is, it will be appreciated, very marked.

These figures, although good, do not indicate the real value of such material, the most noticeable improvement over straight carbon steels being the creep-limit properties at high temperatures. Such properties are of the utmost importance for castings working under high-pressure conditions at elevated temperatures, as it is important that the castings maintain their true shape. The microstructures of the material as annealed and heat-treated (quenched in oil from 900 deg. C., tempered from 600 deg. C.) are illustrated in Figs. 83, 84 and 85.

Manufacture of Rudder Casting (continued).—When the dressing is completed and the material

FIG. 85.—MO STEEL QUENCHED IN OIL FROM 900 DEG. C., TEMPERED FROM 600 DEG. C. × 1,500.

satisfactorily tested and inspected by the overseer, the feeders are cut off by the oxy-acetylene process or by cold saws of the circular or band type. The casting is lined up by the loftsman, and, happily, with regard to this particular casting found to be correct without any setting having to be done. It sometimes happens that a casting is twisted or out of shape, due to the contraction being uneven as a result of local hot parts. In such cases the casting is again set

FIG. 86.—THE SURPLUS METAL BEING MACHINED FROM THOSE PLACES FROM WHICH THE FEEDERS HAVE BEEN REMOVED.

up in the annealing furnace and the twist adjusted. The casting is then turned and bored prior to despatch to the ship department for packing and plating. The machine shown in Fig. 86 is a wall plate, the cutter travelling along the full length of the stock portion of the casting. The placing to the ship of such a casting is not an easy operation, owing to the irregular shapes and weights, and the small working clearances.

The lines of the cast-steel stern frame can also be prominently seen, and the gudgeon, which is part of that casting, forms the hinge on which the rudder swings.

The illustration Fig. 88 shows the contour of a modern design of stern frame, the scantling thickness being as low as ¾ in. in places. The length of one of these pieces is over 33 ft., the contraction on this length being over 6 in. One of the cast-steel shaft brackets can also be seen in Fig. 87 forward of the rudder. It will be appreciated that throughout the various phases of mould manufacture, as illustrated and referred to, a high degree of craftsmanship is exercised.

Moulding by Strickleboards.—The mould shown in Figs. 89, 90 and 91 is built up to design, much as a bricklayer would build a wall, being faced up with a thickness of loam or refractory mortar, by means of which a true-shaped casting can be produced.

(*To be continued.*)

Department of Business Administration

UNIVERSITY OF LONDON

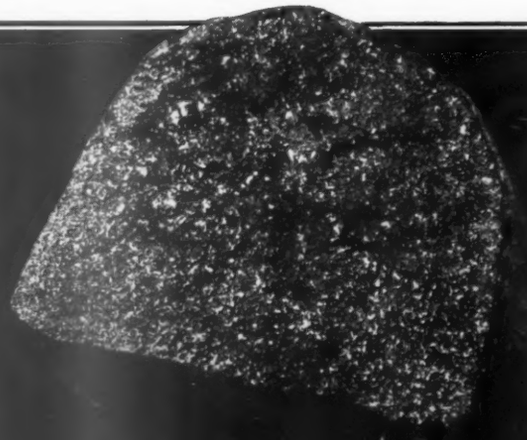
In 1930 a number of business firms pledged their financial support for a five-year experiment in training University men and women for business careers. At their request, and with their co-operation, a new Department of Business Administration was established at the London School of Economics in the University of London. Business men have from the outset played an active part in the work of the Department, taking a share in the responsibilities of management, advising in the scheme of training and investigation, in the appointment of staff and the selection of students, and providing from their varied experience the material upon which the success of such training so largely depends. At the end of the experimental period, the Governors of the London School of Economics have decided, in view of the success which has attended the Department, to make it an integral and more permanent part of the work of the School.

The post-graduate course of training, extending over one year of full-time study, remains the principal work of the Department. For the coming session (October, 1935, to June, 1936) a Leverhulme Scholarship of £200 is offered to enable a University man or woman to attend the course, and four bursaries, equivalent to complete remission of fees, are also offered by the London School of Economics. The course includes business finance and statistics, the various aspects of industrial production and of marketing, management, accounting, questions of personnel and business relations; and attention is concentrated throughout on actual business problems. Visits to factories and trading concerns, and discussions led by prominent business men help to maintain continuous contact with the actual world of business. Students working for higher degrees and wishing to undertake an investigation of a particular business problem as part of their work, may now combine attendance at the post-graduate course with their research. The Department is planning a series of investigations of current problems to be conducted by members of its staff and by research students.

Particulars of the arrangements for the forthcoming session can be obtained from Prof. Arnold Plant, Department of Business Administration, London School of Economics, Houghton Street, Aldwych, London, W.C.2.

XUM

DORMAN LONG



Manufacturers of FOUNDRY, BASIC and HEMATITE qualities. Delivery from stock. Booklet giving analyses, etc., will be sent on request.

DORMAN LONG & CO. LTD.,
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AGENTS IN SCOTLAND:
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PIG IRON

FOUNDRY EXHIBITION

OPENS ON THURSDAY,

SEPTEMBER 12th

AND REMAINS OPEN TILL SEPTEMBER, 28th AT

OLYMPIA – LONDON, W.

11 A.M. TO 9 P.M. DAILY. 1/3 incl. tax.

F. W. BRIDGES & SONS, LTD.
Grand Buildings, Trafalgar Square,
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Cast Camshafts

FORD'S LATEST DEVELOPMENT

An article in a recent issue of "The Iron Age" states that notable savings in production costs and a marked improvement in the quality of the product have resulted from the manufacture of an alloy cast camshaft by the Ford Motor Company for its V-eight cars and trucks. Approximately 6,000 camshafts are made each working day at the Rouge plant by the new process, which was introduced about a year ago.

Most of the rough-machining operations and the heat treatment of the camshaft, both of which were necessary when a forged camshaft was used, have been eliminated since the product has been cast in the Ford foundry. The main bearings of the cast camshaft now show a Brinell reading of 255 and the chilled cams 418. This means that the sturdiness of the camshaft in service, already more than ample to meet all conditions, has been further increased. Perhaps the outstanding achievement technically has been the perfection of the foundry process of making the camshaft so that it has the desired hardness in certain places and desired machinability in other places when cast, thus doing away with heat treatment. Incidentally, the cast camshaft is of the same design as the forged shaft.

Success of the cast camshaft depends on getting a structure with the cam tip hard (chilled) and the centre of the shaft soft (machinable and strong). As the shaft is cast in ordinary green-sand moulds, the depth of the chill and the strength and quality of the grey-iron core is dependent on the analysis of the metal, the coke ratio, the pouring temperature and the amount of moisture in the sand.

Analysis of Mixture

The cast camshaft is of the following analysis: Carbon, 3.30 to 3.65 per cent.; manganese, 0.15 to 0.35 per cent.; silicon, 0.45 to 0.55 per cent.; chromium, 0.00 to 0.25 per cent.; copper, 2.50 to 3.00 per cent.; and phosphorus, 0.05 per cent. maximum. Two standard cupolas are used to melt the charge, which is comprised of 320 lbs. of Bessemer pig-iron, 400 lbs. of camshaft back stock, 80 lbs. of steel scrap and 12 lbs. of copper. The pouring temperature is 2,600 to 2,650 deg. Fah. The cupolas are lined down to 35 in., the coke bed being 36 in. high. Between each charge on an 8-hr. cycle 125 lbs. of coke is added. On the fifth charge 50 extra lbs. of coke is used. A double charge of coke is added at 9.30 a.m. and another at 12.30 p.m. Air pressure in the cupola is 16 to 18 ozs. Output is about 30 tons per cupola every 8 hrs.

Hot metal is tapped from the cupola into 1,200-lb. ladles suspended from an overhead monorail conveyor. An operator pulls the full ladle by hand to a point near the pouring station, where the metal is transferred to hand ladles to be poured into the moulds. Two castings are produced in each mould. There is a core in the front end of each shaft for the undercut in the end of the shaft to aid in machining and grinding the face.

The mould conveyor is oval shaped. Castings are poured as the moulds move slowly along this conveyor. Along one entire side of the conveyor a ventilating hood has been installed to draw off gases from the moulds and the shafts. At the far end of the conveying unit is the shakeout. In the space between the shakeout and the pouring station is a battery of modern moulding machines, where moulds are prepared for the casting operation.

Samples of each heat are taken by pouring bars 1¼ in. in dia. After cooling, the bars are fractured and the depth of the chill is noted. If the chill appears inadequate, powdered ferrochrome up to 0.25 per cent. is added in the ladle. On the other hand, if the chill in the test sample is too deep, small amounts of powdered ferrosilicon are added. An operator is constantly at work noting the fractures and adjusting the chrome and silicon contents to give the proper chill. A flat vent, 1/32-in. thick and as wide as the cam tip, is run up ½-in. from the point of the cam to start the chilling action on the No. 1 cam point, which is near a heavy section. Cams should be file hard on the tips.

All camshafts are impact tested by dropping a 3-lb. 8-oz. weight 30 in. on to the centre main bearing, the shaft being supported during the test on the end main bearings. The test is so severe that it will break shafts with small cracks or shafts which are too brittle.

When the forged camshaft was used there were 61 machining operations on the rough forging. In connection with the present cast camshaft, only 48 machining operations are necessary. The only actual cutting operations are the machining of the construction slot, the cutting of the timing slot and making the centres for grinding the cams.

It is the white iron hard tips on the cams which are responsible for the maximum service given by the cast camshaft. Over 809,000 cast shafts now are in Ford V-eight cars in the hands of the public and no difficulty has been experienced.

Ingot Mould Life

DISCUSSION ON PAPER BY DR. T. SWINDEN AND MR. G. R. BOLSOVER*

MR. E. LONGDEN wrote:—

"The authors are to be congratulated on their practical analysis of the economics of ingot moulds. It is very evident that so long as an accommodating structure is obtained in the mould iron which will respond to the thermal shocks the composition of the metal may vary considerably. What appears important is the method of obtaining the best structure in an iron of a hematite nature and a sound casting.

"It can be deduced from the data in the Paper that the general handling of moulds during the usage plays a more decisive part in the life of same than a variation of as much as 50 per cent. in any of the elements of the mould metal. The analyses stated in the course of the Paper range as follows:—Total carbon from 2.50 to 4.95; silicon, 0.85 to 3.00; manganese, 0.50 to 1.80; phosphorus, 0.03 to 0.23; and sulphur, 0.03 to 0.06 per cent. Average British practice, so far as the writer is aware, does not vary so widely as in the above range of analyses. Probably the average British practice approximates to the following:—Total carbon from 3.65 to 4.00; silicon, 1.50 to 2.50; manganese, 0.65 to 1.25; phosphorus, 0.03 to 0.15; and sulphur, 0.03 to 0.08 per cent.

"Whilst there is very little in the composition range which can be said to approach, or indicate, any degree of scientific control, we, in Britain, evidently work within narrower limits than in other countries.

"There seems little doubt that the principal considerations should be to choose a metal of low sulphur and phosphorus contents and any influences which will create the most stable condition of the carbon, along with an elastic structure. If graphite carbon can, in our considerations of mould metal, be considered as the stable condition of carbon, it will be helpful to approach the maximum of stability prior to placing the mould into use. The act of rapidly heating the inner face of a metal mould to a high temperature is akin to a very irregular annealing.

"Many years ago when engaged on the production of moulds up to 50 tons the writer decided thoroughly to anneal three sizes of moulds below 5 tons. The life of the annealed moulds was greater than the average of the unannealed moulds, but due to a change the final life was not ascertained.

"It may be that a 3.00 per cent. carbon, 1.00 per cent. silicon, 1.00 per cent. manganese, 0.08 per cent. phosphorus, 0.04 per cent. sulphur iron annealed at a temperature of 850 to 900 deg. C. for 48 hours would extend considerably the life of ingot moulds. The carbon change would be more regular across the entire section of the metal. And whilst containing less carbon and silicon than normal mould iron the material would possess a finer structure, thereby less open to gas attack on repeated heating and cooling. Soft cast iron of moderate tensile strength will withstand thermal shock better than a very close-grained cast iron of high tensile strength.

"Upwards of one hundred moulds were at one time made and were machined on the 14 in. internal dia. These moulds were very special for producing alloy steel ingots where the soundness of the ingot metal was of the first importance. The authors do not, as yet, claim any improvement in the life of ingot moulds made from special alloy irons.

"It seems that greater consideration must also be given when designing ingot moulds. Moulds of a composite nature—an assembly of two or more sections—might be a future development. Dr. Hatfield suggests that moulds to produce 250-ton ingots may have to be produced in the future. The cost of such a mould is serious—more so if the life of the mould casting is below the average. It is worth the consideration of the Ingot Mould Committee to study the practicability of producing moulds made up of two or more parts, especially moulds for 100- to 250-ton ingots. Distortion of the sections can be counteracted by design—also the assembly of the sections and care of joints.

"The technique of producing chilled-roll moulds is similar to ingot moulds. The most modern practice for chilled-roll moulds involves the production of composite moulds with the machined surfaces finely slotted. This breaking up of the continuity of the machined surface allows greater freedom for surface expansion and contraction. Crazing of the surface of moulds can thereby be considerably reduced. Many failures of ingot moulds may be attributed to sand mould defects as indicated in Figs. 5 and 6 of the Paper.

"The corner shell—scab defect has been examined by various investigators with metallurgical conclusions because the scab metal contained greater percentages of phosphorus than in the casting generally. Phosphorus can be expected to migrate to the hot corner zones and exude into any cavities or excessive porosity due to late freezing or sand cavity. Corner scabbing can be traced to irregularity in the moulding and drying processes. The mould core should be constructed to avoid any possibility of steam finding an easy passage through the corners of the cores where drying first commences. If the core is packed irregularly so that here and there loosely rammed sand facilitates an easy exit for steam when drying and gases during the pouring of the casting then one can expect a shell scab. Mould cores should be made without strengthening irons which might resist free contraction of the ingot mould casting during cooling."

* FOUNDRY TRADE JOURNAL, August 1, 1935, page 81, and August 15, 1935, page 118.

THE RUMANIAN IRON and steel works have increased their prices owing to difficulties in the importation of raw materials. Concrete bars have been advanced 4.7 per cent.; merchant bars, 4.9 per cent.; black sheets, ½-mm., 15 per cent., and 3 mm., 8 per cent.; galvanised sheets, 10 per cent.; galvanised wire, 6 per cent.; and agricultural machinery, 6.5 per cent., with the exception of certain common agricultural tools.

XUM

FOR STRONG CASTINGS WHICH MACHINE PERFECTLY

WHY WORKINGTON IRONS EXCEL

POINT NO. 2

THE FURNACES

CONSTANCY OF BURDEN MEANS CONSISTENCY OF PRODUCT

Workington policy is to work the burden on uniform high-grade raw materials produced largely under our own control, rather than to draw our supplies from miscellaneous sources, which can only lead to inconsistency.
The Derwent Blast Furnace plant has three modern mechanically-charged furnaces, with a total output of 8000 tons a week. The largest furnace has a weekly output of over 3000 tons—one of the largest units in production in this country.
This furnace is often on the same burden for weeks at a time.
To the foundryman this means that, pig for pig, Workington Iron is correspondingly regular and uniform.
You can rely on Workington Irons.

WORKINGTON IRON AND STEEL COMPANY, WORKINGTON, CUMBERLAND
Branch of The United Steel Companies Limited

WORKINGTON West Coast Hematite PIG IRONS

W22

This Week's News in Brief

Trade Talk

THE ANNUAL MEETING of the German Foundry Owners' Federation will take place on September 17 and 18, at Bad Harzburg.

THE MOULDING SHOP in the foundry of Messrs. Dobbie, Forbes & Company, Larbert, was found to be alight shortly after midnight on August 30. Prompt action by railwaymen and others confined the fire to relatively small limits.

MESSRS. FLEMING & FERGUSON, LIMITED, engineers, Paisley, have secured an order to build a large passenger vessel for Newfoundland. Work on the vessel will commence as soon as possible, and the work will keep the employees busy for some time.

SIR ARTHUR M. SUTHERLAND, chairman of the Tyne-Tees Shipping Company, Limited, of Newcastle-upon-Tyne, announces that his directors are considering building a new motorship for the Rotterdam trade and two new cargo steamers for the London trade, states the Tyneside Industrial Development Board.

EMPLOYEES OF Messrs. Ley's Malleable Casting Company, Limited, and the Ewart Chainbelt Company, of Derby, make weekly contributions to the Ian Forbes Panton Memorial Fund. The money is to be used to endow a bed in the Derbyshire Royal Infirmary. The barometer which hangs in the works yard was designed by one of the draughtsmen and records the week's increase in collections.

AMONG THE LARGEST of the contracts for the Rand Water Board is a share of that for the supply of pipes awarded to Stewarts and Lloyds, Limited, Glasgow, who will share the total of £371,108. Contracts for valves have been secured by Glenfield & Kennedy, Limited, Kilmarnock, for pumps and accessories by Drysdale & Company, Limited, Yoker, Glasgow, and for boilers by Yarrow & Company, Limited, Scotstoun, Glasgow.

MESSRS. ADAMSON, GREEN & COMPANY, LIMITED, electrical switchboard specialists, St. Bede's Works, Felling-on-Tyne, have begun production of an apparatus to determine the moisture content of moulding sands and other substances, including butter, cotton and carcases. It is the invention of Mr. S. E. Dawson, F.I.C., and Mr. F. T. Hanks, and was recently described in our columns. The Tyneside Industrial Development Board states that many inquiries have been received by the manufacturers.

THE FREE STATE CENSUS of production relating to the metal trades, excluding engineering, shows that the value of the gross output in 1933 was £737,965 as compared with £582,362 in 1932. The principal increases were in tinplate and japanned goods (£139,119 as compared with £106,965); girders, beams and joists and iron and steel structural work £99,554 as compared with £62,383; cast-iron articles, external water and soil pipes, gutters, stoves, grates and ranges, etc., £147,408 as compared with £99,772. The value of the net output was £381,162 as compared with £307,673. The number of persons engaged in 1933 was 2,570 compared with 1,947 in the previous year. The amount paid in wages was £207,626 in 1933 and £197,487 in 1932.

BLAST-FURNACE MODERNISATION at the Rouge plant of the Ford Motor Company at Dearborn, Mich., to increase daily pig-iron production at the plant by 300 tons, has been completed. This modernisation scheme, which cost $580,000, is part of a $20,000,000 expansion programme which will provide additions and replacements in nearly all parts of the plant. Blast furnace "B" has been enlarged and rebuilt, increasing its capacity from 500 to 800 tons of pig-iron a day. Its new hearth diameter is 18 ft. 6 in., as compared with 17 ft. before. The diameter of the top has been increased from 16 ft. 2 in. to 18 ft. 3 in. In addition, three hot-blast stoves for furnace "A" have been rebuilt at a cost of $180,000, and new electric precipitators for gas cleaning on both furnaces have been built at a cost of $250,000.

PARTICULARS OF AN ISSUE of £400,000 4½ per cent. first mortgage debenture stock, 1965, have been issued by the Earl of Dudley's Round Oak Works, Limited. The issue is being made in order to repay £330,000 6 per cent. first mortgage debenture stock and to pay off Bank advances. The stock will be redeemed by means of a cumulative sinking fund of 1½ per cent. per annum commencing June 30, 1936. The sinking fund will operate by purchase of stock in the market at or under 102 per cent. or by yearly drawings at that price. The company may at any time on or after December 31, 1940, redeem the whole or part of the stock outstanding at 102½ per cent., plus accrued interest on three months' notice. Any stock not previously redeemed will be repaid at 101 per cent. on August 31, 1965. Interest is payable half-yearly on March 1 and September 1. The first payment of interest, amounting to £2 5s. per cent., less tax, will be made on March 1, 1936. The notice is not an invitation to the public to subscribe, but is issued to comply with the regulations of the Committee of the Stock Exchange.

Contracts Open

Dewsbury, September 16.—Twelve bronze or cast-iron lamp standards, for the Town Council. Messrs. L. G. Mouchel & Partners, Limited, 36, Victoria Street, Westminster, S.W.1.

Cape Town, September 25.—Cast iron pipes, special castings, valves, etc., for the Bellville (Cape Province) Village Management Board. The Department of Overseas Trade. (Reference T.Y. 5,233.)

Singapore, November 4.—Hard brass stop and bib taps, stop tap spindles and hydraulic leather washers, for the Municipal Water Department. The Department of Overseas Trade. (Reference T.Y. 10,080.)

Burton Latimer, September 20.—4,800 yds. of 8-in. dia. cast-iron or spun-iron water main, for the Urban District Council. Messrs. Pick, Everard, Keay & Gimson, 6, Millstone Lane, Leicester. (Fee £2 2s., returnable.)

Brightwalton, September 16.—Construction of a pumping station, and a pressed steel water tank and steel tower, for the Wantage Rural District Council. Mr. J. W. Harris, civil engineer, Willesleigh, East Challow, Wantage. (Fee £2 2s., returnable.)

Northampton, September 19.—Deep well pumping plant, capable of lifting 1,500-2,000 galls. per hr. from a 6-in. borehole 200 ft. deep (Hardingstone waterworks), for the Rural District Council. Mr. R. J. Miller, 20, The Millway, Duston, Northampton.

Mid-Glamorgan, September 16.—8,215 lineal yds. of 3-in. dia. cast-iron pipes, with sluice valves, air valves, hydrants and appurtenant works, and 3,300 lineal yds. of 4-in. dia. and 9,600 lineal yds. of 3-in. dia. cast-iron pipes, sluice valves, air valves, hydrants, for the Mid-Glamorgan Water Board. Messrs. Thomas & Morgan & Partners, civil engineers, 23, Gelliwastad Road, Pontypridd. (Fee £5 5s., returnable.)

Company Report

Yorkshire Amalgamated Products, Limited.—Net profit of company and subsidiaries the year ended March 31, £12,390. Interim dividend of 4 per cent. paid in February, absorbing £3,929, and the directors now recommend a final distribution of 2 per cent., leaving £6,497 to be carried forward. The balance of the profit and loss account as at March 31, 1934, was absorbed in the reconstruction scheme carried through last year.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

The Edinburgh Steel Castings Company, Limited, Gray's Mill, Slateford, Midlothian. Capital £3,000. To carry on the business of iron, steel, and other metal founders and fitters.

Iron and Steel Institute

The Autumn Meeting of the Iron and Steel Institute will be held in Manchester on September 16 to 19.

Personal

THE CHIEF ENGINEER of the "Queen Mary" will be Mr. Llewellyn Roberts, a Welshman, who will take over his duties when the giant vessel goes to sea. A native of Llandudno, Mr. Roberts has spent all his life at sea, and has served in the "Aquitania" and the "Berengaria."

MR. BENJAMIN R. BUCKLEY, on the occasion of his retirement from the Dalzell Steel Works, Motherwell, has been made the recipient of a mahogany writing bureau, the presentation being made by Mr. Fraser, the newly-appointed works manager. Mr. Buckley has just completed over 53 years' service with Colvilles, Limited.

Wills

DUFF, JAMES, manager of the sand-spun pipe department of the Staveley Coal & Iron Company, Limited £5,668

PANTON, IAN FORBES, of Derby, general manager and director of Leyes Malleable Castings, Limited, Derby, and President of the Derbyshire League of Industry £77,995

Obituary

MR. J. A. MUNRO, who had been Irish representative of the firm of Messrs. McDowall, Steven & Company, Limited, ironfounders, Falkirk, for over thirty years, died last week.

MR. CHARLES EDWARD ELLIOTT, who retired five years ago, after 44 years' service with the Vickers Works of the English Steel Corporation, Sheffield, has died, aged 64. For 34 years he was in charge of the gun-treating and building plant. He was awarded the M.B.E. in 1920 for his war services. After his retirement his services were retained in a consultative capacity.

MR. GEORGE KENDALL, of Fencehouses, Co. Durham, has died at the age of 87. He was blower at the Cleveland works of Messrs. Bolckow, Vaughan & Company, Limited, when a 30-cwt. Bessemer converter was used to demonstrate the then new basic process of steelmaking. In 1887 he blew the steel for ingots which won for Bolckow Vaughan's the highest awards at the Newcastle Exhibition.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"OPHINOL."—A liquid preparation for spraying cores and moulds used in the casting of metals. Fordath Engineering Company, Limited, Hamblet Works, Albion Road, West Bromwich.

"CUPSIL."—Metal alloys for electrodes. Holden & Hunt, Cox's Lane Works, Old Hill, Staffordshire.

"HYDRO-GRAPHOLAG."—Graphite for use in the manufacture of founders' blacking. Max Mezger, 2 and 3, Golden Square, London, W.1.

"BRADALLOY."—Piston rings. Bradford Piston & Piston Ring Company, Limited, Albion Works, Greengates, Bradford, Yorkshire.

Royal Air Force Vacancies for Boys.

The Air Ministry announces that vacancies will occur this month for over 300 boy entrants in the Royal Air Force. Entry is open to boys who were between 15¾ and 17¼ on August 1, 1935, and who have attended a secondary, junior technical or central school up to the age of 15½, or have attained an equivalent educational standard. Accepted boys will be given 12 to 16 months' training as wireless operators, armourers and photographers. This method of entry is the normal system of recruiting for the foregoing trades and is independent of the special entry of young men over the age of 17 for training in the same trades which has been authorised in consequence of the expansion of the Royal Air Force. The number of vacancies is, of course, increased as a result of the expansion. Intending applicants should write at once for details of the scheme and application forms to the Air Ministry (Boy Entrants Dept.), Adastral House, Kingsway, London, W.C.2. Candidates will be required to obtain nominations from a recognised authority, which must reach the Air Ministry by September 15 to be in time for the next entry.

XUM

RIXON'S (W'BRO') No. 3 Foundry Iron

A fluid iron for light intricate castings

Builder's Hardware,
Brackets, Holloware,
Gas Stoves, Boilers,
Fenders, Firegrates,
Rainwater and Soil Pipes,
Drainpipes, etc.

Recognized throughout the foundry industry as the leading brand of Northamptonshire iron, Rixon's (W'bro') No. 3 Foundry Pig Iron is produced in modern furnaces solely for the open market. Scientific furnace control enables the elements to be kept within close limits. The relatively high phosphorus content gives this iron a fluidity which makes it particularly suitable for light castings of all types.

Rixon's (W'bro') No. 3 Pig Iron is supplied in notched pigs, already broken in halves and therefore easily handled.

MICRO
50 DIAS:
UNETCHED

ANALYSIS

	Per Cent
Silicon	3.29
Sulphur	0.025
Phosphorus	1.65
Manganese	0.34
Graphitic Carbon	3.52
Combined Carbon	0.12
Total Carbon	3.64

THE STANTON IRONWORKS COMPANY LIMITED

NEAR NOTTINGHAM

The largest producers of Pig Iron (for Sale) in Great Britain

Raw Material Markets

The majority of the works continue to have well-filled order-books and, although new business is not plentiful, the undertone is quite sound. The call for pig-iron has been maintained, but as the principal consumers are, in most cases, well covered until the end of the year, the number of inquiries has been restricted. Business in semi-finished materials is good and some heavy deliveries are being made. Export business for finished products is quiet, but numerous inquiries are forthcoming on home account.

Pig-Iron

MIDDLESBROUGH.—Producers in this area have very little iron for sale for early delivery. The majority of consumers are well covered for their immediate requirements, and consequently the resumption of trade after the holidays has not been too good. Should an increase in demand occur, producers will have to light more furnaces in order to satisfy consumers' needs. Foundry iron sales are almost entirely to home buyers, and the export trade is very poor. Home values are based on No. 3 Cleveland G.M.B. at 67s. 6d. per ton in the Middlesbrough area, 69s. 6d. delivered North-East Coast, 67s. 3d. delivered Falkirk, and 70s. 3d. delivered Glasgow. The price of No. 1 foundry iron is 2s. 6d. per ton more and No. 4 foundry and No. 4 forge iron are 1s. per ton less than No. 3.

Hematite producers have sold almost all their output to the end of the year and their position is very satisfactory. The Italian trade has not yet been resumed, but the likelihood of this happening has been made less remote by some former debts being liquidated to some extent. The principal quotations for No. 1 East-Coast grade are 71s. per ton delivered Middlesbrough, 72s. delivered Tyneside, 73s. 6d. delivered elsewhere in the North-East Coast, 77s. 6d. delivered Scotland, and 78s. 6d. delivered Sheffield.

LANCASHIRE.—Very little new business is coming forward. Most consumers have already covered their requirements. Light-castings makers, jobbing foundries and some general engineers are taking deliveries, as also are a few speciality branches, including heavy electrical engineering, and machine tool making, but on the whole there is very little new business to report. Offers of Derbyshire, Staffordshire and Lancashire brands of No. 3 foundry iron equal to Derbyshire are all on the basis of 74s. per ton delivered Lancashire area, with Northants at 72s. 6d. and Scottish foundry at around 81s. 6d. West-Coast hematite is at 81s. delivered Manchester, and East Coast is at from 80s. to 81s., according to brand

MIDLANDS.—Ironfounders are in a very satisfactory position in this district, and with the holiday interruptions almost at an end the market has become more active. Some consumers are contemplating covering their needs as far ahead as June of next year, and others are covered up till the end of 1935. Quotations delivered Birmingham and Black Country stations and subject to rebate to large consumers are 67s. 6d. for Northants No. 3 and 71s. per ton for Derbyshire, Lincolnshire and North Staffordshire No. 3. Forge prices are still 5s per ton below No. 3 iron. Scottish No. 3 and other low-phosphorus irons are quoted from 85s. to 90s. per ton, medium-phosphorus 72s. to 82s. 6d., and special refined pig-iron from £5 7s. 6d. to £7 per ton delivered South Staffs. Hematite prices are as follow:—84s. 6d. per ton for West Coast mixed numbers, 84s. for East Coast No. 1, and 83s. for Welsh mixed numbers, delivered to South Staffordshire works in 10-ton lots.

SCOTLAND.—Hematite and basic brands of iron are being steadily consumed in this area, but otherwise there is very little of note to report. Prices remain unchanged, and No. 3 foundry is at the official minimum of 70s. f.o.t. furnaces, with 2s. 6d. per ton extra for No. 1. English foundry in addition to local iron is being taken up by the light-castings manufacturers, who continue to be satisfactorily occupied. Official quotations for Cleveland iron are unchanged, No. 3 foundry being at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow, with other English irons 1s. 3d. per ton less. Steel-making irons, which are being well taken up, are:—Mixed numbers Scottish hematite, 73s. 6d., ordinary mixed numbers West Coast hematite, 75s.; ordinary mixed numbers East Coast hematite, 77s. 6d.; basic, British and Indian, 70s., less 5s. rebate, all delivered f.o.t. steelworks here. Scottish hematite is 2s. 6d. higher on the week.

Coke

The market for cupola coke is still weak, and forward buying transactions are still very few. However, prices have not fallen, and are unchanged on the week. For delivery to Birmingham and district stations best Durham coke is 34s. to 40s., and Welsh from 31s. 6d. to 43s. 6d. per ton.

Steel

Rather more active conditions have developed in the steel markets, and the volume of inquiry indicates that a healthy revival in business is likely to follow the holiday season, states the official report of the London Iron and Steel Exchange. Owing to the heavy forward covering which took place at the end of July and in August, new business is somewhat restricted, but a fair amount of day-to-day buying is being transacted in most departments. Business in semi-finished steel has broadened appreciably, and lately the works have added a considerable tonnage to their order-books. In some cases consumers are pressing for delivery, and all the works making this class of material are well employed. No fresh offerings of Continental semi-finished steel are expected for several weeks. Some improvement in the export demand for finished-steel materials is reported, while the home trade, after a period of rather quiet business, has again become active. Large tonnages of structural steel are passing into circulation, and the demand shows no signs of decreasing. In other departments of the finished-steel industry also the home market requirements are on an expanding scale.

Scrap

Regular deliveries of scrap are being taken by the foundries in the Cleveland area. Prices are unchanged. Ordinary foundry cast iron may be obtained at 52s. 6d. per ton, and good machinery metal, broken to convenient sizes, realises up to 55s. Light cast iron is offered at 42s. to 42s. 6d. and cast-iron borings realise 27s. 6d. per ton delivered works. The South Wales market is featureless. Light cast iron is at 42s. 6d. to 45s. per ton, and good cast-iron machinery scrap in foundry sizes remains at from 52s. 6d. to 54s. Business in the Midland market is mostly in small parcels for early delivery. Heavy wrought-iron scrap is 57s. 6d. and clean cast-iron borings are at 30s. Heavy machinery metal in cupola sizes is at 55s. to 57s. 6d., good heavy at 50s. and clean light at 47s. 6d. Prices on the Scottish market are firm and business is steady. Consumption has increased and deliveries are now being made without interruption. Good piling wrought-iron scrap is at 57s. 6d. and has a firm call. Rough and small wrought iron remains at 52s. 6d. with shovelling wrought iron at about 5s. per ton less. Machinery cast-iron scrap in pieces not more than 1 cwt. in weight is firm at 56s. 6d. to 57s. 6d., delivered f.o.t. consumers' works.

Metals

Copper.—Profit-taking following the recent advance was chiefly responsible for the setback in prices which has occurred lately. The London market has been rather irregular for some time now, but reports from the United States indicate a very large consumption in that country.

Daily market prices:—

Cash.—Thursday, £33 2s. 6d. to £33 3s. 9d.; Friday, £33 7s. 6d. to £33 8s. 9d.; Monday, £33 to £33 1s. 3d.; Tuesday, £33 2s. 6d. to £33 3s. 9d.; Wednesday, £32 16s. 3d. to £32 17s. 6d.

Three Months. — Thursday, £33 10s. to £33 11s. 3d.; Friday, £33 15s. to £33 17s. 6d.; Monday, £33 7s. 6d. to £33 8s. 9d.; Tuesday, £33 10s. to £33 11s. 3d.; Wednesday, £33 5s. to £33 6s. 3d.

Tin.—Interest in the tin market has been shown by consumers on the Continent and in South Wales. It is expected that the tinplate industry will continue to take steady deliveries. In the United States the demand for tin has decreased, in contrast to the active conditions that were recently ruling.

Day-to-day fluctuations:—

Cash.—Thursday, £221 5s. to £221 10s.; Friday, £221 15s. to £222 10s.; Monday, £220 5s. to £220 15s.; Tuesday, £220 15s. to £221; Wednesday, £219 10s. to £220.

Three Months.—Thursday, £211 10s. to £211 15s.; Friday, £212 to £212 5s.; Monday, £210 2s. 6d. to £210 7s. 6d.; Tuesday, £210 5s. to £210 10s.; Wednesday, £209 to £209 5s.

Spelter.—Trade demand for spelter has been fairly extensive, and the market has had quite a good appearance. The new British duties having now been put into operation, the question of reconstituting the International Zinc Cartel has again been raised. The general opinion is, however, that the interested parties will not meet until the new duties have been in operation for some considerable time.

Official quotations were as follow:—

Ordinary.—Thursday, £15 11s. 3d.; Friday, £15 7s. 6d.; Monday, £14 18s. 9d.; Tuesday, £15 1s. 3d.; Wednesday, £14 18s. 9d.

Lead.—This market is in a very sound position, and the demand from home consumers has been satisfactory. The pipe and sheet trade and the solder manufacturers are taking up large quantities of lead. Since the new duty came into force business has been rather disappointing, but the last few days have seen an increase. It is, of course, too early to judge the ultimate effect of the duty on trade. The world output for July increased by 6,400 short tons over the total for the previous month.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £15 15s.; Friday, £15 12s. 6d.; Monday, £15 11s. 3d.; Tuesday, £15 13s. 9d.; Wednesday, £15 11s. 3d.

London Course in Foundry Practice

The Sir John Cass Technical Institute, Jewry Street, Aldgate, E.C.3, announces that a course on Foundry Practice will be pursued on Monday evenings from 7 to 10 p.m. commencing September 23. The teacher is Mr. A. F. Gibbs a Past-President of the London Branch of the Institute of British Foundrymen. This course and a second one held on Wednesdays from 7 to 9.30 p.m. prepares candidates for the City and Guilds Examination.

The Principal (Mr. Geo. Patchin, A.R.S.M.) will be pleased to supply a copy of the syllabus of the City and Guilds Examination in Foundry Practice and also of the other courses given in the Department of Metallurgy.

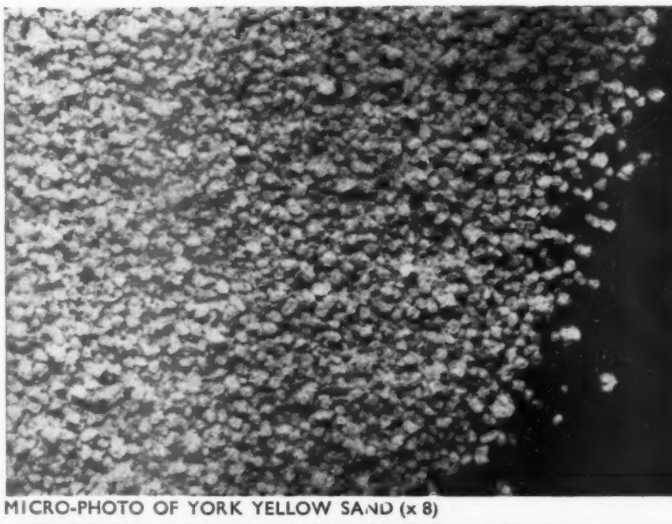
It is interesting to note that last year was distinguished by the number of academic successes gained by students of the Institute.

IDAHO PINE
YELLOW PINE

PRIME & PATTERN GRADES
½" to 3" thick
Width up to 24" wide
All free of centre heart and shake

CHETHAM TIMBER
Co., Ltd.,
70, FINSBURY PAVEMENT,
LONDON, E.C.2
Metropolitan 7418

Moulders who want a sand with that little extra resistance for casting iron and iron alloys at high temperature, and which will produce a good skin on the casting, will find no better medium than York Yellow Sand. It is well bonded, fine in grain, yet permeable and highly refractory.



YORK YELLOW

MICRO-PHOTO OF YORK YELLOW SAND (x 8)

GENERAL REFRACTORIES LIMITED.

Telephones:	*Head Office:*	*Telegrams:*
Sheffield 22311 (5 lines).	Genefax House, Sheffield.	Genefax, Sheffield.
	London Office:	
London 7361 Temple Bar.	Russell House, Adelphi, W.C.2.	Genefax, Rand, London.
	Glasgow Office:	
Central 5250.	156, St. Vincent Street, C.2.	Genefax, Glasgow.

XUM

RAW MATERIALS—PRICE LIST

(Wednesday, September 4, 1935)

COPPER

	£	s.	d.
Standard cash	32	16	3
Three months	33	5	0
Electrolytic	36	15	0
Tough	35	0	0
Best selected	35	15	0
Sheets	64	0	0
India	47	5	0
Wire bars	37	2	6
Ingot bars	37	2	6
H.C. wire rods	40	15	0
Off. av. cash, August	32	13	6½
Do., 3 mths., August	33	1	0½
Do., Sttlmnt., August	32	13	5½
Do., Electro, August	36	5	0
Do., B.S., August	35	10	10
Do., wire bars, August	36	10	5½
Solid drawn tubes			10d.
Brazed tubes			10d.
Wire			6d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11¼d.
Rods, drawn	8d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7⅝d.
Wire	7½d.
Rolled metal	7½d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5⅞d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£	s.	d.
Standard cash	219	10	0
Three months	209	0	0
English	219	10	0
Bars	220	10	0
Straits (nom.)	220	0	0
Australian (nom.)	220	0	0
Eastern	215	10	0
Banca (nom.)	221	10	0
Off. av. cash, August	223	4	8⅔
Do., 3 mths., August	212	19	8⅞
Do., Sttlmt., August	223	4	3⅞

SPELTER

	£	s.	d.
Ordinary	14	18	9
Remelted	15	15	0
Hard	12	10	0
Electro 99.9	17	12	6
English	16	0	0
India	13	5	0
Zinc dust	19	10	0
Zinc ashes	3	5	0
Off. aver., August	14	16	6 7/16
Aver. spot, August	14	14	3⅞

LEAD

	£	s.	d.
Soft foreign ppt.	15	11	3
Empire (nom.)	16	6	3
English	17	10	0
Off. average, August	15	15	7½
Average spot, August	15	15	5½

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	5	0
Do., V.M. ex-whse.	24	5	0
Rods	29	0	0

ANTIMONY

	£	s.	d.		£	s.	d.
English	74	0	0	to	75	0	0
Chinese, ex-whse.					66	10	0
Crude, c.i.f.					27	10	0

QUICKSILVER

	£	s.	d.		£	s.	d.
Quicksilver	11	0	0	to	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£12 15 0
75%	£17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£17 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£33 10 0
4/6% car.	£21 15 0
6/8% car.	£21 0 0
8/10% car.	£21 0 0
Ferro-chrome—	
Max. 2% car.	£34 0 0
Max. 1% car.	£36 5 0
Max. 0.70% car.	£37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to 11 5 0
76/80% packed	£11 15 0 to 12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 5/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel	2	15	0	to	2	16	0
Bundled shrngs.	2	7	6	to	2	16	0
Mixed iron and steel	2	10	0	to	2	12	0
Heavy cast iron	2	10	0	to	2	12	0
Good machinery	2	12	6	to	2	15	0
Cleveland—							
Heavy steel				2	12	6	
Steel turnings				1	17	6	
Cast-iron borings				1	7	6	
Heavy cast iron				2	12	6	
Heavy machinery				2	15	0	
Midlands—							
Light cast-iron scrap				2	7	6	
Heavy wrought iron				2	17	6	
Steel turnings				1	14	0	
Scotland—							
Heavy steel				2	10	0	
Ordinary cast iron				2	12	6	
Engineers' turnings				2	0	0	
Cast-iron borings	1	17	6	to	1	18	9
Wrot-iron piling				2	17	6	
Heavy machinery				2	16	6	

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	27	0	0
Brass	18	0	0
Lead (less usual draft)	13	10	0
Tea lead	10	0	0
Zinc	9	10	0
New aluminium cuttings	67	0	0
Braziery copper	23	0	0
Gunmetal	25	0	0
Hollow pewter	150	0	0
Shaped black pewter	116	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	71/-
Hematite M/Nos.	70/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	75/-
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	73/6
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
W.C. hematite	86/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	81/6
Clyde, No. 3	81/6
Monkland, No. 3	81/6
Summerlee, No. 3	81/6
Eglinton, No. 3	81/6
Gartsherrie, No. 3	81/6
Shotts, No. 3	81/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)	9	12	6	to	9	15	0
Nut and bolt iron	7	10	0	to	8	0	0
Hoops	10	10	0	and up.			
Marked bars (Staffs) f.o.t.				12	0	0	
Gas strip	10	10	0	and up.			
Bolts and nuts, ¾ in. × 4 in.				14	2	6	and up.
Steel—							
Plates, ship, etc.	8	15	0	to	8	17	6
Boiler plts.	9	5	0	to	9	7	6
Chequer plts.				10	7	6	
Angles				8	7	6	
Tees				9	7	6	
Joists				8	15	0	
Rounds and squares, 3 in. to 5½ in.				9	7	6	
Rounds under 3 in. to ⅜ in. (Untested)				8	12	0	
Flats—8 in. wide and over				8	12	6	
,, under 8 in. and over 5 in.				8	17	6	
Rails, heavy	8	5	0	to	8	10	0
Fishplates	12	5	0	to	12	10	0
Hoops (Staffs)				9	7	0	
Black sheets, 24g. (4-t. lots)				11	0	0	
Galv. cor. shts. (,,)				13	0	0	
Galv. flat shts. (,,)				13	10	0	
Galv. fencing wire, 8g. plain				14	10	0	
Billets, soft	5	10	0	and up.			
Billets, hard	6	17	6	to	7	2	6
Sheet bars	5	5	0	to	5	10	0
Tin bars	5	5	0	to	5	10	0

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9¾d.
Sheet to 10 w.g.	11½d.
Wire	12d.
Rods	11d.
Tubes	13½d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.31
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 21/-
Durham foundry	20/- to 21/-
,, furnace	16/6 to 17/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 and up.
,,	28×20 ,,	36/4 and up.
,,	20×10 ,,	26/- to 26/3
,,	18¾×14 ,,	18/9 to 19/-
C.W.	20×14 ,,	15/6
,,	28×20 ,,	32/6
,,	20×10 ,,	22/9
,,	18¾×14 ,,	15/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.		£	s.	d.
Pig-iron	6	0	0	to	7	0	0
Bars-hammered, basis	16	0	0	to	16	10	0
Bars and nail-rods, rolled, basis	15	15	0	to	16	0	0
Blooms	10	0	0	to	12	0	0
Keg steel	30	0	0	to	31	0	0
Faggot steel	18	0	0	to	23	0	0
Bars and rods dead soft, st'l	10	0	0	to	12	0	0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Aug. 29 ..	33 2 6 dec.	1/3
,, 30 ..	33 7 6 inc.	5/-
Sept. 2 ..	33 0 0 dec.	7/6
,, 3 ..	33 2 6 inc.	2/6
,, 4 ..	32 16 3 dec.	6/3

Electrolytic Copper

	£ s. d.	
Aug. 29 ..	36 10 0 dec.	5/-
,, 30 ..	37 0 0 inc.	10/-
Sept. 2 ..	36 15 0 dec.	5/-
,, 3 ..	36 15 0 No	change
,, 4 ..	36 15 0 ,,	,,

Standard Tin (cash)

	£ s. d.	
Aug. 29 ..	221 5 0 inc.	15/-
,, 30 ..	221 15 0 ,,	10/-
Sept. 2 ..	220 5 0 dec.	30/-
,, 3 ..	220 15 0 inc.	10/-
,, 4 ..	219 10 0 dec.	25/-

Tin (English ingots)

	£ s. d.	
Aug. 29 ..	221 10 0 inc.	20/-
,, 30 ..	222 0 0 ,,	10/-
Sept. 2 ..	220 10 0 dec.	30/-
,, 3 ..	221 0 0 inc.	10/-
,, 4 ..	219 10 0 dec.	30/-

Spelter (ordinary)

	£ s. d.	
Aug. 29 ..	15 11 3 inc.	2/6
,, 30 ..	15 7 6 dec.	3/9
Sept. 2 ..	14 18 9 ,,	8/9
,, 3 ..	15 1 3 inc.	2/6
,, 4 ..	14 18 9 dec.	2/6

Spelter (Electro, 99.9 per cent.)

	£ s. d.	
Aug. 29 ..	18 2 6 inc.	1/3
,, 30 ..	17 18 9 dec.	3/9
Sept. 2 ..	17 11 3 ,,	7/6
,, 3 ..	17 15 0 inc.	3/9
,, 4 ..	17 12 6 dec.	2/6

Zinc Sheets (English)

	£ s. d.	
Aug. 29 ..	23 10 0 inc.	5/-
,, 30 ..	23 7 6 dec.	2/6
Sept. 2 ..	23 0 0 ,,	7/6
,, 3 ..	23 5 0 inc.	5/-
,, 4 ..	23 5 0 No	change

Lead (English)

	£ s. d.	
Aug. 29 ..	17 15 0 dec.	5/-
,, 30 ..	17 10 0 ,,	5/-
Sept. 2 ..	17 10 0 No	change
,, 3 ..	17 10 0 ,,	,,
,, 4 ..	17 10 0 ,,	,,

AVERAGE MONTHLY PRICES OF DERBYSHIRE NO. 3 FOUNDRY AT MANCHESTER.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1899	2 13 0	2 14 0	2 14 0	2 14 0	3 0 0	3 2 0	3 13 0	3 16 6	3 15 0	3 16 6	3 16 6	4 0 0	3 6 2½
1900	4 0 0	4 0 0	4 0 0	4 1 6	4 1 0	3 18 0	3 13 6	3 12 6	3 11 0	3 11 0	3 9 6	3 8 0	3 15 5
1901	2 13 6	2 17 0	2 15 0	2 15 0	2 14 0	2 13 9	2 13 6	2 13 6	2 14 6	2 13 0	2 12 6	2 16 6	2 14 3½
1902	2 17 6	2 17 6	2 15 6	2 16 9	2 16 6	2 16 6	2 16 6	2 17 0	2 18 6	2 18 6	2 17 6	2 17 6	2 17 1½
1903	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1904	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1905	2 13 0	2 13 0	2 11 6	2 12 6	2 12 0	2 12 0	2 12 3	2 12 3	2 14 0	2 16 6	3 0 0	3 0 6	2 14 1
1906	3 2 0	3 5 0	3 3 0	3 0 6	2 17 0	2 18 6	2 18 0	2 16 6	2 19 0	3 0 6	3 1 6	3 7 0	3 0 8½
1907	3 7 0	3 7 0	3 5 0	3 2 0	3 4 0	3 8 0	3 6 0	3 5 0	3 4 0	3 2 6	3 1 0	2 18 6	3 4 2
1908	2 15 0	2 14 6	2 14 6	2 15 6	2 14 0	2 13 0	2 13 0	2 11 6	2 12 6	2 13 0	2 12	2 12 6	2 13 5½
1909	2 13 0	2 12 6	2 11 6	2 12 0	2 12 6	2 12 6	2 12 0	2 12 6	2 14 6	2 15 0	2 14 6	2 14 0	2 13 0½
1910	2 13 9	2 14 0	2 14 0	2 14 4	2 15 0	2 15 0	2 14 9	2 15 0	2 15 0	2 15 0	2 15 0	2 15 0	2 14 7½
1911	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 14 6	2 15 0	2 15 0	2 15 8½
1912	2 17 4½	2 17 6	2 17 6	3 1 1½	3 2 6	3 3 9	3 6 3	3 7 6	3 10 10½	3 12 6	3 13 3½	3 14 6	3 5 4
1913	3 15 7	3 15 0	3 11 10½	3 11 4½	3 10 2½	3 6 10½	3 4 2½	3 2 9	3 1 9	3 1 0	2 19 3	2 17 2½	3 6 5
1914	2 17 2½	2 18 0	2 18 0	2 17 0	2 17 0	2 16 7½	2 16 0	3 2 10	3 1 0	2 19 9½	2 16 11½	2 18 1½	2 18 2
1915	3 1 2	3 3 11	3 5 9	3 18 8½	3 13 7	3 14 1	3 15 0	3 13 3	3 12 0½	3 11 1	3 14 0	4 3 3	3 12 2½
1916	4 4 6½	4 11 6	4 11 6½	4 7 6	4 7 6	4 7 6	4 10 0	4 12 10	4 12 6	4 12 6	4 12 6	4 12 6	4 8 6½
1917	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1918	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1919	4 12 6	4 12 6	4 12 6	4 12 6	7 2 6	7 5 0	8 8 5	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	7 3 10
1920	9 13 9	10 0 0	10 5 3	10 15 3	11 10 0	12 2 6	12 5 0	13 1 3	14 7 6	14 5 0	14 5 0	14 5 0	12 12 1½
1921	12 11 8	10 8 9	9 2 6	8 2 0	8 0 0	8 0 0	8 0 0	8 1 8	7 4 0	6 7 6	5 7 6	4 1[illegible] 10	8 0 2
1922	5 5 0	4 17 6	4 15 0	4 15 0	4 12 6	4 12 6	4 12 6	4 12 6	4 11 3	4 10 0	4 10 0	4 10 0	4 13 7½
1923	4 12 8½	5 0 2	6 2 6	6 8 7½	6 2 5	5 11 9	5 9 1½	5 4 0	5 0 0	5 0 9	5 0 7	5 2 9	5 7 11½
1924	5 3 0	5 3 0	5 3 0	5 3 0	5 2 10	5 1 3	4 17 11	4 15 6	4 13 6	4 10 1½	4 10 0	4 10 3	4 17 9½
1925	4 10 0	4 9 0	4 6 9	4 5 2½	4 3 0	4 0 1½	4 17 1½	3 15 7½	3 14 3½	3 13 4½	3 13 4½	3 13 2½	4 1 9
1926	3 14 9	3 15 3	3 15 6	3 15 3½	3 17 6	4 5 9	4 16 9	*	*	*	*	4 12 6	4 0 1½
1927	4 13 9½	4 13 3	4 11 1½	4 9 4½	4 6 1½	3 19 1½	3 16 1½	3 15 6	3 13 4½	3 13 4½	3 14 0	3 13 6½	4 1 6½
1928	3 13 2½	3 12 3½	3 12 3	3 12 3	3 11 6	3 10 0	3 8 3	3 7 8½	3 7 6	3 7 9½	3 8 3	3 7 6	3 9 10½
1929	3 8 3½	3 10 4½	3 10 10½	3 11 0	3 11 2½	3 12 0	3 12 4½	3 14 6	3 15 1½	3 17 0	3 17 0	3 17 0	3 13 1½
1930	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 15 0	3 12 0	3 12 0	3 12 0	3 10 1½	3 9 6	3 14 4½
1931	3 9 6	3 9 6	3 9 6	3 9 6	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 10
1932	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0
1933	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0
1934	3 7 0	3 9 6	3 13 2½	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 12 11½
1935	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	—	—	—	—	—

* No prices available during strike period.

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